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FOCUSED REMEDIAL INVESTIGATION AND FEASIBILITY STUDY FOR GROUNDWATER REMEDIATION AT OPERABLE UNIT 1 (OU 1) NAS JACKSONVILLE FL

7/1/1994

ABB ENVIRONMENTAL

FOCUSED REMEDIAL INVESTIGATION (RI) AND FOCUSED FEASIBILITY STUDY (FS) FOR

ADDRESSING GROUNDWATER REMEDIATION

OPERABLE UNIT 1
NAVAL AIR STATION JACKSONVILLE, FLORIDA

Contract Task Order No. 0057

Contract No. N62467-89-D-0317

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FOREWORD

To meet its mission objectives, the U.S. Navy performs a variety of operations, some requiring the use, handling, storage, or disposal of hazardous materials. Through accidental spills and leaks and conventional methods of past disposal, hazardous materials may have entered the environment in ways unacceptable by today's standards. With growing knowledge of the long-term effects of hazardous materials on human health and the environment, the Department of Defense (DOD) initiated various programs to investigate and remediate conditions related to suspected past releases of hazardous materials at their facilities.

One of these programs is the Navy and Marine Corps Installation Restoration (IR) program. This program complies with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). The Acts, passed by Congress in 1980 and 1986, respectively, established the means to assess and clean up hazardous waste sites for both private-sector and Federal facilities. These Acts are the basis for what is commonly known as the Superfund program.

Originally, the Navy's part of this program was called Naval Assessment and Control of Installation Pollutants (NACIP) program. Early reports reflect the NACIP process and terminology. The Navy eventually adapted the program structure and terminology of the IR program.

The IR program is conducted in several stages as follows:

- The Preliminary Assessment (PA) identifies potential sites through record searches and interviews.

- A Site Inspection (SI) then confirms which areas contain contamination, constituting actual "sites." (Together, the PA and SI steps were called the Initial Assessment Study [IAS] under NACIP.)

- Next, the Remedial Investigation and the Feasibility Study (RI/FS) together determine the nature and extent of contamination, establish criteria for cleanup, identify and evaluate any necessary remedial action alternatives, and develop cost estimates of each alternative. As part of the RI/FS, a Risk Assessment is made to identify potential effects on human health and the environment to help evaluate remedial action alternatives. To expedite cleanup, RI/FS activities can be focused to remediate specific sources of contamination at a site before completing the RI/FS for the entire site.

- The selected alternative is planned and executed in the Remedial Design and Remedial Action (RD/RA) stages. Monitoring then ensures the effectiveness of the effort.

The investigations of potential hazardous waste sites at Naval Air Station (NAS) Jacksonville, Florida, are presently being executed under the IR program and follow CERCLA guidelines. Earlier preliminary investigations had been conducted at NAS Jacksonville, Florida, under NACIP. In 1990, in coordination with the U.S. Environmental Protection Agency (USEPA) and the Florida Department of Environmental Regulation (FDER), the investigation of hazardous waste sites were formalized under a Federal Facilities Agreement (FFA).

NAS Jacksonville, Florida, is conducting the investigation and cleanup of hazardous waste sites at their facility by working through the Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM). The USEPA and FDER, now known as the Florida Department of Environmental Protection (FDEP), oversee the Navy environmental program. All aspects of the program are conducted in compliance with State and Federal regulations, as ensured by the participation of these regulatory agencies.

Questions regarding the IR program at NAS Jacksonville, Florida, should be addressed to Mr. Joel G. Murphy, Code 1853, Remedial Project Manager, at (803) 743-0577.

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GLOSSARY

ABB-ES	ABB Environmental Services, Inc.
bls	below the land surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CLEAN	Comprehensive Long-term Environmental Action, Navy
CLP	Contract Laboratory Program
cm/sec	centimeters per second
CPR	Contaminant Plume Reduction
DOD	Department of Defense
DPT	direct push technology
FDEP	Florida Department of Environmental Protection
FDER	Florida Department of Environmental Regulation
FFA	Federal Facilities Agreement
FRI	Focused Remedial Investigation
FS	Feasibility Study
ft/ft	feet per foot
GAC	granular activated carbon
GC	gas chromatography
GMS	Groundwater Migration Stabilization
gpm	gallons per minute
H_2O_2	hydrogen peroxide
IAS	Initial Assessment Study
IR	Installation Restoration
IROD	Interim Record of Decision
K	hydraulic conductivity
LNAPL	light nonaqueous-phase liquid
LSA	LNAPL source area
NACIP	Naval Assessment and Control of Installation Pollutants
NAS	Naval Air Station
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
O_3	ozone
OU	Operable Unit

GLOSSARY (Continued)

PCBs	polychlorinated biphenyls
PSC	Potential Source of Contamination
psi	pounds per square inch
QA/QC	quality assurance/quality control
RAOs	remedial action objectives
RD/RA	Remedial Design and Remedial Action
RI	Remedial Investigation
RI/FSWP	Remedial Investigation/Feasibility Study Workplan
SARA	Superfund Amendments and Reauthorization Act
SI	Site Inspection
SOUTHNAVFACENGCOM	Southern Division, Naval Facilities Engineering Command
SQLs	sample quantitation limits
SVE	soil vapor extraction
SVOCs	semivolatile organic compounds
TAL	target analyte list
TBC	to be considered
TCL	target compound list
USDON	U.S. Department of the Navy
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UV	ultraviolet
VOCs	volatile organic compounds

1.0 INTRODUCTION

ABB Environmental Services, Inc. (ABB-ES), under the Comprehensive Long-term Environmental Action, Navy (CLEAN) Contract No. N62467-89-D-0317 is preparing a Remedial Investigation (RI) and Feasibility Study (FS) on behalf of the U.S. Department of the Navy (USDON), Southern Division, Naval Facilities, Engineering Command (SOUTHNAVFACENGCOM), at the Naval Air Station (NAS) Jacksonville, Florida (Figure 1-1). NAS Jacksonville is participating in the U.S. Department of Defence Installation Restoration (IR) program, which identifies and remediates conditions related to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and with the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) (U.S. Environmental Protection Agency [USEPA], 1990). CERCLA and SARA, passed by Congress in 1980 and 1986, respectively, establish the means to assess and clean up hazardous waste sites.

NAS Jacksonville was placed on the USEPA's National Priority List (NPL) in December 1989. In October 1990, a Federal Facility Agreement (FFA) was signed by the USEPA, the Florida Department of Environmental Regulation (FDER), now the Florida Department of Environmental Protection (FDEP), and the Navy to coordinate IR program actions at NAS Jacksonville.

Three Operable Units (OU) have been identified at NAS Jacksonville. RI/FS activities have been initiated at OU 1, which is located in the south-central portion of the facility (Figure 1-2). OU 1 consists of Potential Source of Contamination (PSC) 26, known as the Old Main Registered Disposal Area, and PSC 27, known as the Former Polychlorinated Biphenyl (PCB) Transformer Storage Area (Figure 1-3).

Volume 1 of the Navy Installation Restoration Program Plan for NAS Jacksonville, Organization and Planning (Geraghty & Miller, 1991b), Volume 4, Base Site Work Plan (Geraghty & Miller, 1991c, updated 1992), Volume 5, Book 1 of 2, Operable Unit 1 Remedial Investigation/Feasibility Study Workplan (RI/FSWP) (Geraghty & Miller, Inc., 1991c), and Guidance for Conducting Remedial Investigations and

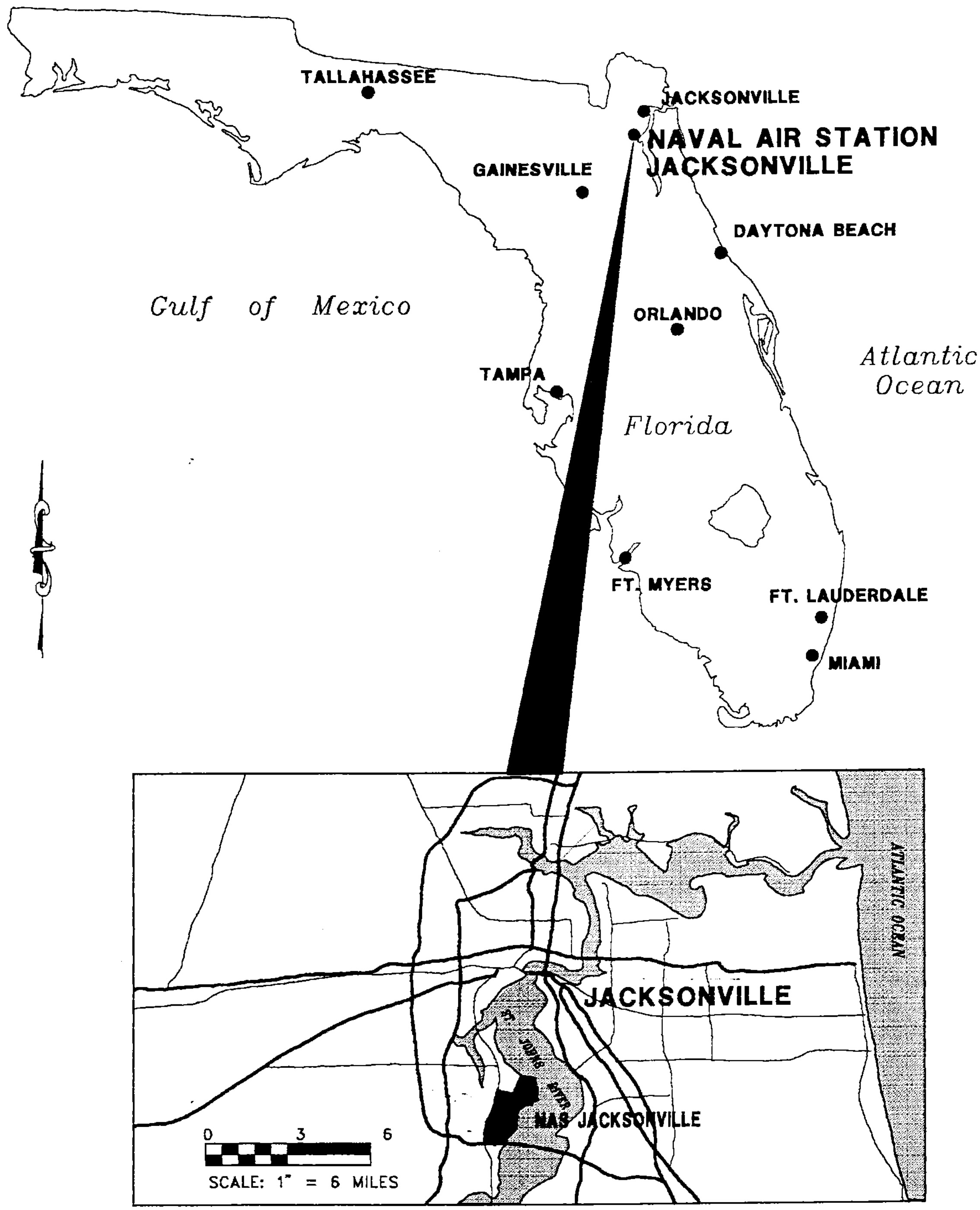

FIGURE 1-1
FACILITY LOCATION MAP

FOCUSED RI/FS
CONTAMINANT PLUME
REDUCTION AT OU 1

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JACKSONVILLE, FLORIDA

JAXSITE/DRM/7-12-94

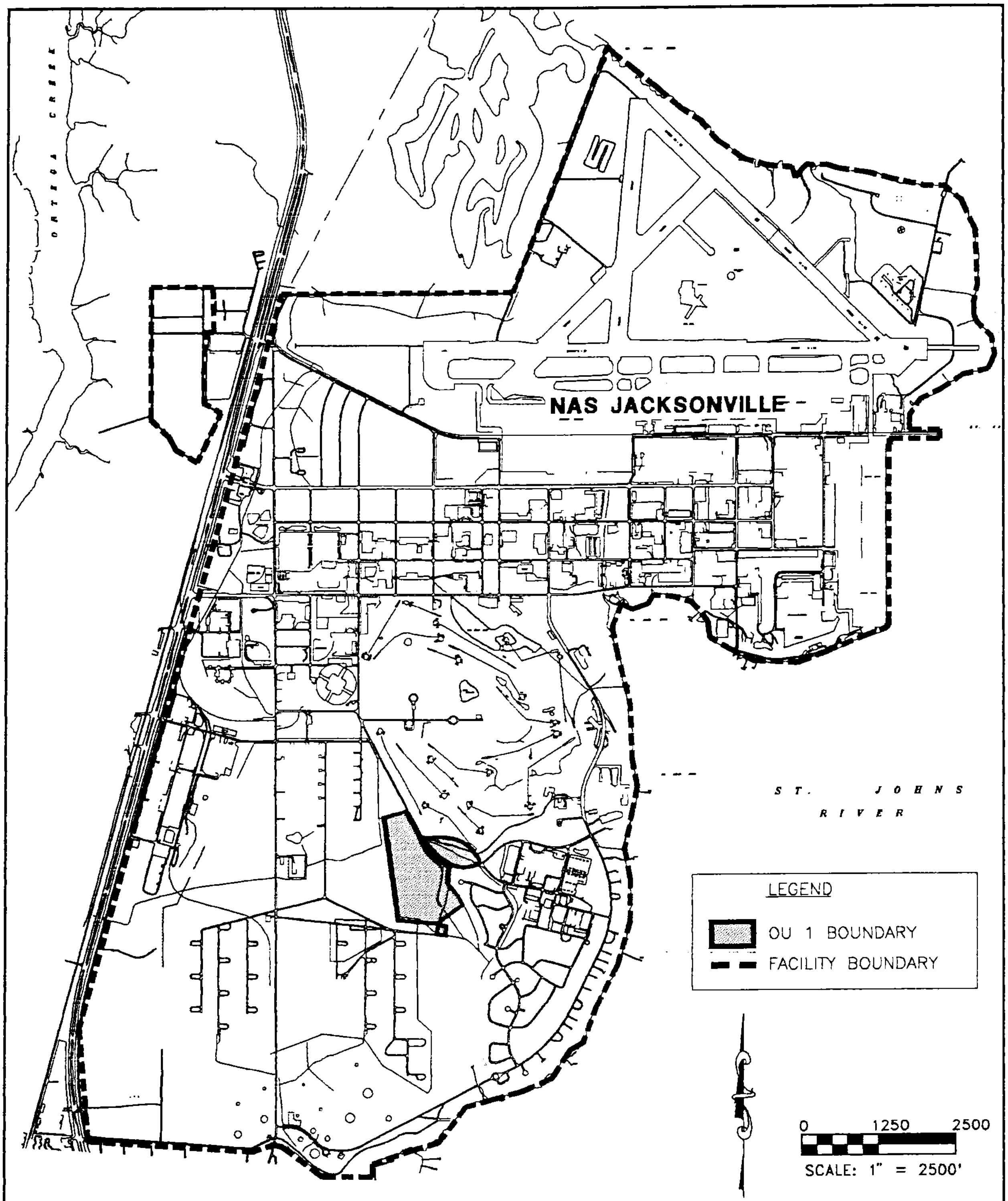


FIGURE 1-2
FACILITY MAP AND LOCATION OF OU 1

FOCUSED RI/FS CONTAMINANT PLUME REDUCTION AT OU 1

NAS JACKSONVILLE
JACKSONVILLE, FLORIDA

JAX200/DRM/7-12-94

Feasibility Studies under CERCLA (USEPA, 1988) were used as guidance materials for the Focused RI/FS.

Volume 5 Book 1 of 2 (Gerahgty & Miller, 1991b) also details the tasks and activities for the phase one RI field investigation at OU 1. The appendices for the OU 1 workplan include the OU 1 Sampling and Analysis Plan (comprising the Field Sampling Plan and the OU 1 site-specific Quality Assurance Project Plan) and the OU 1 site-specific Health and Safety Plan.

Volume 5, Book 2 of 2 (ABB-ES, 1991), 'Preliminary Characterization Summary Report' presents a summary of phase one (now defined as round one) RI field activities, field data, laboratory data, findings, conclusions, and recommendations for the OU 1.

Based on the findings presented in Chapter 5.0 of the Preliminary Characterization Summary Report (ABB-ES, 1991) for OU 1, the following immediate remedial actions were initiated at OU 1.

1. <u>Focused RI/FS for Light Non-aqueous Phase Liquid (LNAPL) Removal</u>. As a result of the identification of LNAPL on the surficial aquifer at PSC 26, a Focused RI/FS was completed in December 1993. This report addresses remedial alternatives for the LNAPL source area and recommends a preferred remedial alternative for removal of LNAPL within the shallow surficial aquifer at OU 1.

2. <u>Focused RI/FS for Reducing Volatile Organic Contaminants in Groundwater.</u> As a result of the identification of groundwater contaminants in the shallow aquifer system (10 to 40 feet beneath the land surface), a Focused RI/FS was proposed to be completed to address the volatile organic contaminants in groundwater at OU 1.

This report represents the Focused RI/FS for groundwater at OU 1 and is the second in a series of two reports generated for OU 1 to address the remedial actions presented in the previous paragraph.

1.1 PURPOSE AND SCOPE. The purpose of this Focused RI/FS at OU 1 is to:

- define the nature and extent of contamination within the groundwater based on the round 2 RI field investigation at OU 1, and

- present technologies and remedial alternatives appropriate to address groundwater contamination at OU 1.

The scope of the focused RI was limited to investigation of groundwater. As such, the results and conclusions of the field investigations are limited to characterization of the extent of groundwater contamination at OU 1. Because of the focused nature of this study, data gathered during the field effort were not intended to be used to fully characterize the nature and extent of contamination at OU 1, nor were they intended to be used to support a baseline risk assessment. These tasks will be completed during execution of the overall RI/FS for OU 1. Similarly, the remedial alternatives discussed in this report are not intended to provide permanent solutions to all risks associated with contamination at OU 1. However, mitigating/reducing migration of volatile organic compound (VOC) contaminants in groundwater will eliminate a portion of those risks while maintaining consistency with the overall remedial strategy for OU 1.

1.2 REPORT ORGANIZATION. This Focused RI/FS report consists of the following sections:

1.0 INTRODUCTION. This chapter presents the purpose and scope of the Focused RI/FS.

2.0 OPERABLE UNIT 1, FOCUSED REMEDIAL INVESTIGATION (RI). This chapter presents an overview of OU 1, describes field activities and findings associated with the Focused RI, identifies data gaps, and recommends additional investigations to fulfill the data gaps for implementing Focused Feasibility Study at PSCs 26 and 27.

3.0 APPLICABLE, OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) SUMMARY. This chapter includes a summary of the location-, chemical-, and action-specific applicable or relevant and appropriate requirements (ARARs) for OU 1.

4.0 IDENTIFICATION OF REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS. This chapter develops remedial action objectives for groundwater at OU 1. General response actions are also presented in this section. In addition, quantities of contaminated media of concern are estimated.

5.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES. This chapter identifies a select number of technologies appropriate for addressing VOC contaminants in groundwater at OU 1.

6.0 DETAILED ANALYSIS OF ALTERNATIVES. This chapter describes each developed remedial alternative and presents a technical assessment of each remedial alternative based on criteria stipulated by CERCLA.

7.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES. This chapter presents a comparative analysis of the alternatives that underwent detailed analysis in chapter 6.0 relative to one another.

2.0 FOCUSED REMEDIAL INVESTIGATION (FRI)

This chapter presents an overview of OU 1, describes field activities and findings associated with the Focused RI, identifies data gaps, and recommends additional investigations to fulfill the data gaps for completing Focused Feasibility Study at PSCs 26, and 27.

2.1 OVERVIEW OF OPERABLE UNIT (OU) 1. This section presents the site description and history of OU 1 at NAS Jacksonville. A complete description of the history of OU 1 is contained in the RI/FS workplan for OU 1 (Geraghty & Miller, 1991b).

2.1.1 Site Description OU 1 is located off Child Street in the south-central portion of NAS Jacksonville. OU 1 is composed of two PSCs, PSCs 26 and 27 (Figure 1-2). PSC 26 is the Old Main Registered Disposal Area. PSC 27 is the former PCB Transformer Storage Area and is located in the southeast corner of OU 1.

The major portion of OU 1 is located on the south side of Child Street and is approximately 38 acres in size. It is bordered on the north by Child Street, on the east by a base residential area, on the south by a wooded area, and on the west by a weapons storage area. An additional 3 acres of PSC 26 are located on the north side of Child Street (Figure 1-3).

2.1.2 Site History A detailed description of the history of OU 1 is contained in the RI/FS Workplan for OU 1 (Geraghty & Miller, 1991b). The following is a summary of the site history for OU 1.

- Prior to 1940, the site was operated by the U.S. Army and was used for disposal of non-hazardous waste and debris.
- From 1940 to 1950, the U.S. Navy reportedly disposed of radium-228 paint wastes and luminescent dials in a portion of PSC 26.
- From 1940 to 1979, the U.S. Navy used PSC 26 for the disposal of household (glass, wood, metal, plastic, foodstuffs, and other household

items) and sanitary waste, liquid industrial waste (oil and spent solvents), and demolition and construction debris. Liquids were placed in open pits or trenches and ignited (Figure 1-2). After the disposal pits were full of burned residues, they were covered with soil and graded to conform with the surrounding topography.

- Burning of liquid wastes was discontinued at an unknown date. However, disposal of waste oil and solvents continued at PSC 26 until LNAPL was discovered seeping into a man-made drainage ditch in 1978. The U.S. Navy officially closed PSC 26 as a disposal site on January 15, 1979.

- LNAPL was discovered in the shallow surficial aquifer in 1979. Twenty-one monitoring wells were drilled in the vicinity of the oil and solvents disposal pits at PSCs 26 and 27 in 1980. Analyses of groundwater samples indicated the presence of VOCs and inorganics at concentrations exceeding drinking water standards.

- An Initial Assessment Study (IAS) was completed at NAS Jacksonville in 1982. Ten sites, including PSCs 26 and 27, were determined to pose potential threats to human health and the environment.

- An LNAPL recovery system was constructed north and southwest of Child Street in 1983 by a Navy contractor and operated until 1984. This system included: two exfiltration galleries, a perimeter drainage ditch system, two underflow weirs, a flow-measuring weir, and skimmers to collect recovered LNAPL. Prior to startup of the recovery system, materials in the primary disposal pits (Figure 1-2) were excavated to a depth of 8 feet. The excavated materials were mixed with sandy fill material and spread over OU 1 to a minimum depth of 10 inches. The entire land surface was then graded to drain to the engineered ditch system.

- Removal of recoverable LNAPL was initiated in September 1983. The quantity of LNAPL recovered during the system's operation is unknown. The recovery system was shut down in 1984 when the discharge from the drainage ditch system failed to meet National Pollutant Discharge Elimination System (NPDES) permit requirements. Earthen dams were subsequently constructed across the ditches to prevent offsite drainage from OU 1. Though other investigative activities continued at OU 1, no other attempts were made to recover LNAPL.

- NAS Jacksonville was placed on the NPL and an FFA among the Navy, the USEPA, and FDER was signed in 1990.

- In 1990, a cone penetrometer survey was completed in the area around the old waste oil and solvents pits. The results of the study provided a qualitative indication of the LNAPL contamination present in the soil at OU 1 and within the LNAPL Source Area (U.S. Army Corps of Engineers, 1991).

- In 1992, the phase one RI field activities at OU 1 were conducted. The results of these activities are summarized in the Preliminary Charaterization Summary Report (ABB-ES, 1992).

2.2 SUMMARY OF PREVIOUS INVESTIGATIONS. ABB-ES completed the phase one RI at OU 1 from January through July 1992. The RI program included the following tasks:

- geophysical survey;
- soil gas sample collection;
- ambient air sample collection;
- surface soil sample collection;
- borehole soil sample collection;
- surface water and sediment sample collection;
- monitoring well and piezometer installation;
- groundwater sample collection;

- monitoring well, piezometer, and sample location topographic survey;

- *in-situ* slug testing of aquifer properties at monitoring wells and piezometers;

- laboratory analyses of environmental samples for USEPA target compound list (TCL) organics, target analyte list (TAL) inorganics, cyanide, dioxins and furans, and radionuclides; and

- ecological inventory.

Standard data validation and quality control procedures were used during the RI program. For a detailed description of the RI program components, refer to the following sections of the RI/FS Workplan for OU 1:

- Volume 1, Appendix 1.5, Site Health and Safety Plan;

- Volume 4, Appendix 4.1, RI/FS Workplan Quality Assurance/Quality Control (QA/QC) Plan;

- Volume 4, Appendix 4.2, Data Analysis Plan;

- Volume 4, Appendix 4.4, Basic Sampling and Analysis Plan;

- Volume 5, Section 5.0, Remedial Investigation Field Tasks; and

- Volume 5, Appendix 5.6, PCSR (for Workplan deviations and changes).

For the purposes of the FRI/FFS, hydrogeologic conditions, soil and groundwater analytical results, and the LNAPL constituent analyses are summarized and discussed in the following subsections.

<u>2.2.1 Hydrogeologic Conditions</u> Water level measurements, oil-water interface measurements, and groundwater elevations were recorded for all onsite wells and piezometers. These data were used to determine the horizontal and vertical flow

directions and velocities of groundwater. Potentiometric surface maps were completed from these data.

Depth to groundwater in the shallow surficial aquifer ranged from 2 feet to 15 feet below the land surface (bls). The data indicate that this aquifer flows under unconfined and, in localized areas, semiconfined conditions. The primary vector of the groundwater flow in the shallow surficial aquifer is to the southeast, although there appears to be a topographic high in the north-central portion of OU 1 from which flow radiates outward.

LNAPL was found in three shallow surficial monitoring wells: MW-9, MW-13, and MW-29 (Figure 1-3). MW-9 and MW-13 are within the LNAPL Source Area (LSA). LNAPL thicknesses ranged from 4 to 5 feet in MW-13, and from 0.5 foot to 2 feet in MW-9. MW-29 was reported to have contained LNAPL during the second and third rounds of water level measurements at a thickness of 0.02 foot. No measurable LNAPL has been noted in this well since these measurements.

In-situ rising head and falling head slug tests were performed on 20 wells screened in the shallow surficial aquifer. The range of calculated hydraulic conductivity (K) was from 5.3×10^{-4} to 6.5×10^{-5} centimeters per second (cm/sec). These estimated values are consistent with ranges estimated for typical unconsolidated materials found at OU 1, include fine sands, silty sands, and clayey sands (ABB-ES, 1992).

Based on the potentiometric surface data, the horizontal gradient for groundwater flow in the shallow surficial aquifer ranges from 0.0089 to 0.44 foot per foot (ft/ft) at OU 1, with an average hydraulic gradient of 0.0065 ft/ft. Information regarding the vertical groundwater velocities at MW-9 or MW-13 was not available, but one well cluster in the LSA (MW-11/MW-12) consistently showed a downward vertical gradient, whereas another (MW-7/MW-8) exhibited both an upward and downward gradient during the separate water level measurements. The magnitude of these gradient changes is unknown.

For more information regarding the hydrogeologic conditions at OU 1, refer to the PCSR (ABB-ES, 1992), Section 4.2, Hydrogeologic Conditions.

2.2.2 Soils Assessment The purpose of the soils investigation at OU 1 was to determine the horizontal and vertical extent of contamination of OU1 site soils and to support a preliminary assessment of the site soils and exposure pathways available for human or ecological receptors. Contaminants detected in the soil samples consist of volatiles and semivolatile organic compounds (SVOCs), pesticides, inorganics, PCBs, dioxins and furans, and radionuclides. The highest concentrations of soil contamination were detected in the vicinity of the former solvent and waste disposal pit areas. Contaminants also were detected at lower concentrations in surface soil samples (less than 6 inches beneath the land surface) in various portions of OU 1.

For further information on soil sample analytical results, refer to the PCSR (ABB-ES, 1992), Subsection 4.3.4, Soil Sample Results.

2.2.3 Groundwater Assessment The purpose of the groundwater investigation at OU1 was to determine the groundwater quality and support preliminary assessment of groundwater exposure pathways available for human or ecological receptors. Monitoring Well installation and groundwater sampling at OU 1 occurred from April to June 1992. Contaminants were not detected in the monitoring wells installed in the intermediate zone of the Hawthorn Formation (115 to 120 feet beneath the land surface). Monitoring wells installed in the Shallow Aquifer System (10 to 40 feet beneath the land surface) contained concentrations of volatile and semivolatile organics, pesticides, metals, and radionuclides. A detailed description of analytical results of Round 1 groundwater sampling, are provided in the PSCR Report (ABB-ES, 1992).

2.3 SCOPE OF THE FRI. The Focused RI was conducted from August 1993 to March 1994 to delineate the groundwater contamination at OU 1 NAS Jacksonville. The Focused RI was part of the OU 1, Round 2, RI. The following Focused RI field activities took place as part of the Focused RI:

- Direct push technology (DPT) screening sampling at 90 locations to determine the VOC contaminants in groundwater and to select monitoring well locations;

- installation of monitoring wells (shallow and deep surficial) to confirm the findings of the groundwater screening program, establish permanent locations for the long-term monitoring of water quality, and provide data to support the FFS;

- hydraulic conductivity testing of newly installed monitoring wells and groundwater sampling of all monitoring wells; and

- a locational survey of DPT sample locations and monitoring wells; and

- groundwater modelling studies to assess groundwater quality and capture zone analysis of the VOC groundwater plume.

2.4 FIELD PROGRAM SUMMARY.

2.4.1 DPT Groundwater Screening DPT exploration, conducted between August 30, 1993, and October 30, 1993, was utilized to collect groundwater samples for field and laboratory analysis to identify and characterize the extent of contaminant plume at OU 1. The DPT methodology included continuous electric cone penetrometer (Piezocone) soundings of the subsurface. The Piezocone continuously measures tip pressure, sleeve friction, and pore pressure of the geologic media in 5/100th of a foot intervals as the probe is pushed through the media. These measurements are used to classify soil type according to the Unified Soil Classification System. In addition, the DPT utilized a computer monitored groundwater sampling system (hydrocone) that measures volume and rate of flow into the sampler and calculates an estimated horizontal permeability.

Initial DPT points were selected based on historical information concerning the landfill boundaries and previously identified groundwater quality data. Samples collected for screening were analyzed in the field by gas chromatography (GC) for VOC target constituents listed in USEPA Methods 601 and 602 and approximately 10 percent of the collected samples were split and submitted to an offsite laboratory for Contract Laboratory Program (CLP) analysis of TCL VOCs to confirm the results of the earlier screening. Ninety-two DPT locations (Figure 2-1) were investigated as part of the Round 2 activities. Samples were collected from different depth intervals at ninety of the locations. The explorations were aborted at DPT-12 and 13 because of buried refuse. The DPT groundwater samples were generally collected near the top of the water table (ranging from 4.5 to 11 feet bls) and near the bottom of the surficial aquifer between 30 to 50 feet bls at each location. Locations near the landfill were sampled at three different intervals (shallow, intermediate, and deep) and locations further from the landfill were sampled at only the deep interval.

The results of the 167 samples that were screened in the field are presented in Appendix A and will be discussed in Section 2.5. The results of the samples split for Offsite laboratory analysis also included in Appendix A and are discussed in Section 2.2.

2.4.2 Installation of Contamination Delineation Wells and Groundwater Sampling

The analytical results of the field screening were used to select the location of permanent monitoring wells that are referred to as Contamination Delineation wells. The monitoring wells, installed between October 11, 1993, and November 22, 1993, were used to delineate the extent of contamination at OU 1. In addition, the Contamination Delineation wells are intended to be used as permanent locations for the long term monitoring of groundwater and will provide data to support FFS. Shallow and deep surficial well pairs were installed at sixteen locations and one deep well was paired with Water Quality/Flow Modelling well MW-66. Figure 2-2 shows the location of the 33 Contamination Delineation wells and Figure 2-3 shows the location of the 35 Water Quality/Flow Modelling wells. Only 4 of the Water Quality/Flow modelling wells (MW-58, 59, 61, and 67) are considered to be part of the investigation of the extent of contamination as presented in this FRI/FS. Monitoring well installation logs of the Contamination Delineation and the 4 Water Quality/ Flow Modelling wells are included in Appendix B.

The Contamination Delineation Wells were sampled between November 29, 1993 and December 9, 1993 as part of the Round 2 activities. Each sample was analyzed for the Contract Laboratory Procedure TCL for VOCs, SVOCs, pesticides and PCBs, TAL total metals and cyanide, dissolved metals, and gamma scan (USEPA 901.1). The results of the groundwater sampling are presented in Appendix C and discussed in Section 2.5.

A second (Round 2) groundwater sampling event was conducted, for VOCs only, between March 7 and 18, 1994. This sampling event included all shallow and deep surficial Round 1 monitoring wells except those with LNAPL present (MW-9, 13, and 29), Round 2 wells MW-58, 59, 61, and 67, and all contaminations delineation wells (i.e., MW-84 through MW-116). The results of the VOC sampling event are included in Appendix C and summarized in Section 2.5.

<u>2.4.3 Slug Tests for Aquifer Characterization</u> Hydraulic conductivity tests were performed, between December 13, 1993 and January 5, 1994, on the Contamination Delineation wells. Hydraulic conductivity is estimated from *in-situ* rising head and falling head slug tests as well as from the DPT hydrocone sampling activity. Due to the difference in stratigraphic layers, a limited amount of drawdown produced by slug testing, and the relatively rapid recovery of static water levels in the wells, the hydraulic conductivity values for the materials in which the wells are screened are qualitative indicators of the characteristics in the immediate vicinity of the wells. Therefore, each individual value for a particular well location does not necessarily reflect area-wide aquifer properties. A summary of the hydraulic conductivity results are presented in Appendix D.

<u>2.4.4 Groundwater Flow Analysis</u> The U.S. Geological Survey (USGS) conducted a hydrological investigation of the aquifer and surface waters at OU 1 on December 16, 1993 and on January 27, 1994. The USGS's activities included potentiometric surveys of the surficial aquifer and flow measurements of the basewide streams including those adjacent to OU 1. USGS utilized this information to develop a hydrological model, using MODFLOW software, of the aquifer located at OU 1. Based on the hydrogeologic setting, USGS has initiated evaluation of groundwater extraction for both plume reduction and restoration.

The purpose of USGS groundwater flow studies at OU 1 include the following.

- Evaluate the groundwater flow beneath the OU 1 and the base flow to the adjacent surface water streams.

- Collect necessary field measurements to calibrate the USGS MODFLOW model for the hydrogeologic system at the OU.

- Predict the groundwater flow patterns for several remediation scenarios for groundwater.

Findings of the groundwater flow modelling studies are included in Section 2.5.

<u>2.5 FINDINGS OF THE FOCUSED RI</u>. The focused RI findings include the results of the hydraulic conductivity tests and groundwater analyses of the Round 2 activities, as well as a comparative discussion of Round 1 and 2 data, including the second Round 2 sampling event for VOCs.

<u>2.5.1 **Results of Slug Tests**</u> The estimated values for the hydraulic conductivities at OU 1 range from 1.0E-03 cm/sec to 2.0E-05 cm/sec for the 33 VOC Contamination Delineation Wells and range from 4.0E-03 cm/sec to 2.0E-06 cm/sec for the 90 hydrocone (DPT) measurements. The hydraulic conductivity results are presented in Appendix D.

<u>2.5.2 **Groundwater Assessment**</u> Table 2-1 presents a summary of the concentrations exceeding the sample quantitation limits (SQLs) from Round 1 and 2 data, including the second Round 2 sampling event for VOCs. The laboratory and field analytical results of groundwater samples obtained from the surficial aquifer at OU 1 indicate the presence of a groundwater plume of dissolved contamination underlying the landfill area and to the east under portions of the golf course and base housing area of OU-1. A contour map of total VOCs, including both field GC screening and CLP analyses, is presented in Figure 2-4. The identified groundwater contamination is comprised mostly of chlorinated solvents (trichloroethene, tetrachloroethene, and vinyl chloride) and fuel constituents (benzene, toluene, ethylbenzene, and xylene). The direction of contaminant migration appears to be eastward towards the St. Johns River. Figure 2-5 presents the plan view of cross-sections AA'. Figure 2-6 presents the vertical cross section of the VOC contaminant plume along AA' (direction groundwater flow at the OU) based on the groundwater samples collected during 1992 and 1993. Figure 2-7 presents the vertical cross section of the VOC contaminant plume along AA' based on the groundwater samples collected during 1992, 1993 and additional samples collected during 1994.

Table 2-1 Title

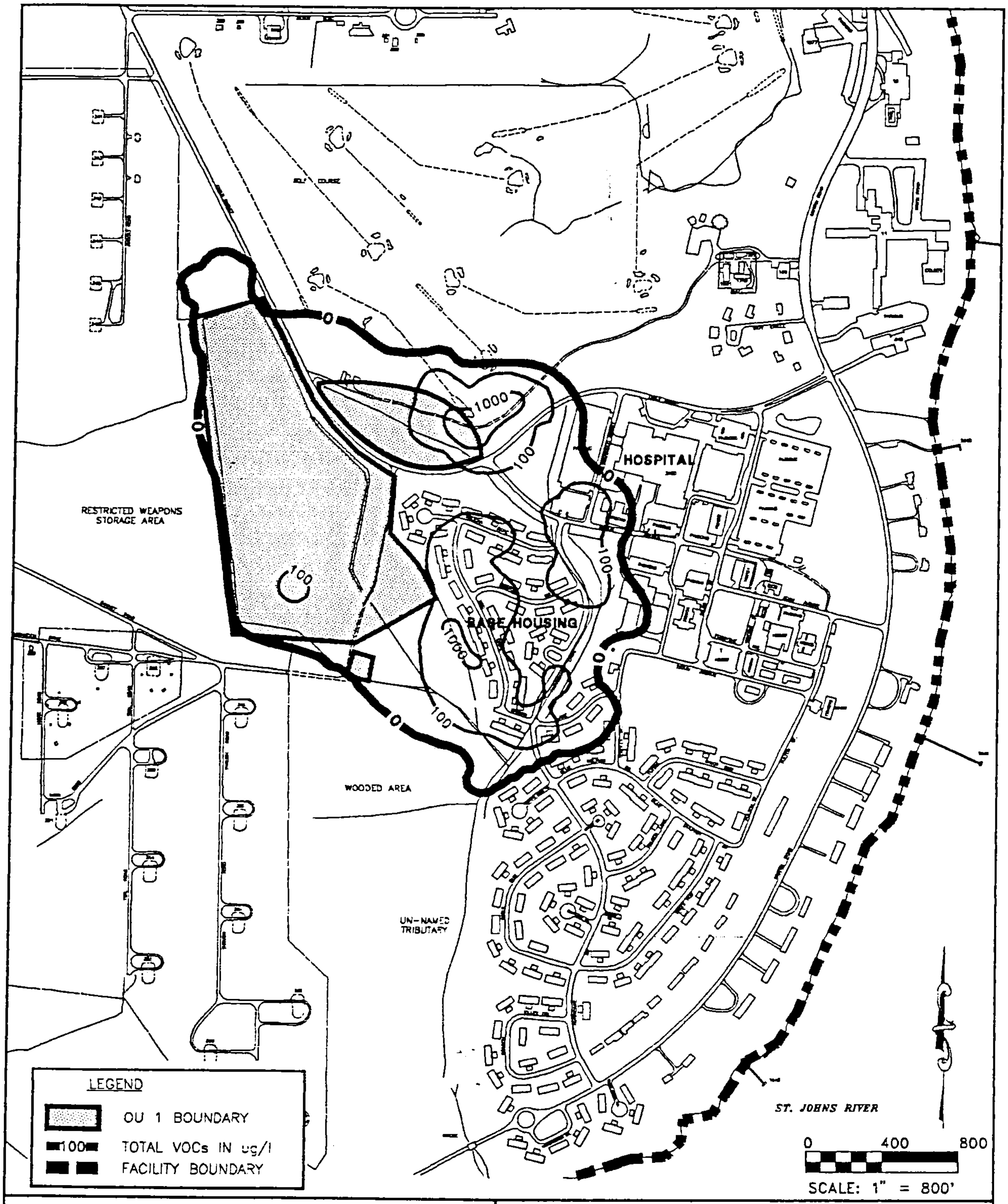


FIGURE 2-4
CONTOUR MAP OF TOTAL VOCs AT OU 1 (JULY 1993 AND MARCH 1994 DATA)

FOCUSED RI/FS CONTAMINANT PLUME REDUCTION AT OU 1

NAS JACKSONVILLE
JACKSONVILLE, FLORIDA

OU1PUMP/DRM/7-15-94

Approximate dimensions of the total VOC contaminant plume at OU 1, are 3000 feet on length, 2,500 feet wide, and 25 feet thick. The plume is located to a maximum depth of approximately 40 feet at the down gradient edge.

<u>2.5.3 Groundwater Flow Analysis</u> Results of preliminary hydrological modeling studies through MODFLOW, by the USGS are summarized as follows.

- Surface migration of the VOC contaminated groundwater plume appears to be limited by the surface water stream adjacent to OU 1 (see Figure 2-8).

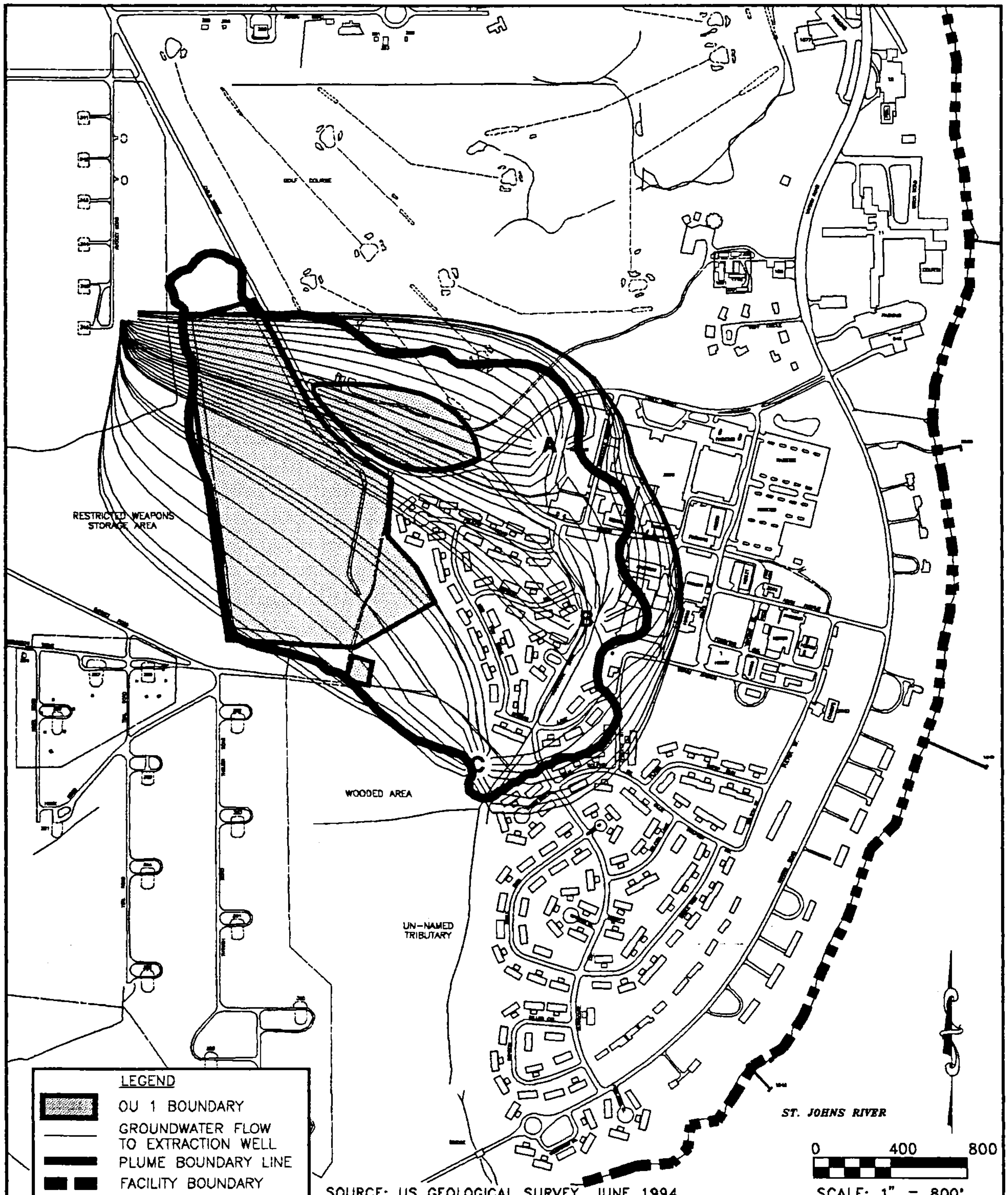
- The base flow to the surface water stream from the groundwater is currently estimated at 80 gallons per minute (gpm) measured at the confluence of the OU 1 trenches and the stream south of OU 1 (see Figure 2-9).

- An optimum location of extraction wells for the groundwater remediation system was evaluated. The preliminary modeling supports installation of three extraction wells A, B, and C with extraction rates of 10, 5, and 10 gpm respectively.

A detailed discussion on USGS investigations is presented in Appendix E.

<u>2.6 DATA GAPS</u>. Groundwater flow analysis was based on the hydraulic conductivity results obtained from the slug tests conducted during RI Round 1, and 2. This data is used primarily to support a cleanup decision. More accurate information on aquifer properties will be required to calibrate and validate the numerical model used to evaluate the groundwater flow at OU 1. The most accurate information is obtained by conducting pump tests, by installing a pumping well in the same formation, and pumping at the same rate as the proposed groundwater remediation system.

Pumping tests can be used to determine the hydraulic properties of the aquifers and aquitards within the area of interest, and to evaluate the performance and



SOURCE: US GEOLOGICAL SURVEY, JUNE 1994.

FIGURE 2-9
GROUNDWATER FLOW LINES TO EXTRACTION WELLS A, B, AND C

FOCUSED RI/FS CONTAMINANT PLUME REDUCTION AT OU 1

NAS JACKSONVILLE JACKSONVILLE, FLORIDA

OU1PUMP/DRM/7-18-94

effectiveness of a groundwater remediation system. These tests are used to measure aquifer parameters such as transmissivity, hydraulic conductivity, and the storage coefficient. These parameters are used to estimate the flow rate, the optimal pumping rate for groundwater extraction in the case of pump and treat systems, optimal location of extraction wells and plume migration behavior. Appendix E includes preliminary guidelines for pump tests at OU 1.

3.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The identification of Federal and State ARARs, along with other available non-promulgated advisories, to be considered requirements (TBCs), and guidance material is an important component in the planning, evaluation, and selection of remedial actions.

The RI/FS Basic Site Workplan (Volume 4, Section 6.1) (Geraghty & Miller, 1991a) and the RI/FS Workplan for OU 1 (Volume 5, Section 3.3) (Geraghty & Miller, 1991b) provide a summary of the types, definitions, and sources of potential ARARs for the NAS Jacksonville IR program as a whole and the OU 1 RI/FS, respectively.

This chapter presents and discusses ARARs specific to addressing groundwater contamination at OU 1. Sections 3.1 and 3.2 identify and define location- and chemical-specific ARARs, respectively. Section 3.3 discusses various action-specific ARARs that may be appropriate for a remedial action to address groundwater contamination; the applicability of these action-specific ARARs will be discussed during the detailed analysis of remedial alternatives in Chapter 6.0.

3.1 LOCATION-SPECIFIC ARARs. Location-specific requirements govern site features (e.g., wetlands, floodplains, and sensitive ecosystems) and manmade features (e.g., places of historical or archaeological significance). These ARARs generally place restrictions on the concentrations of hazardous substances or the conduct of activities based solely on the site's particular characteristics or location.

Based on a review of OU 1 site features (including the engineered and natural ditches shown on Figure 1-2), the regulated location-specific site features are wetlands, floodplains, and sensitive ecosystems. Table 3-1 presents the location-specific ARARs for an interim action to address the groundwater contamination at OU 1.

Table 3-1
Synopsis of Federal and State Location-Specific ARARs

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Federal or State Standards and Requirements	Requirements Synopsis	Consideration in the Remedial Response Process
Endangered Species Act [50 CFR Part 402]	This act requires action to avoid jeopardizing the continued existence of listed endangered or threatened species or modification of their habitat.	Investigation and/or remediation that may impact a rare species or habitat (e.g., gopher tortoise), requires notification to the USEPA and minimization of the adverse effects to such endangered species due to remedial activities. Identification of endangered species at OU 1 was conducted during the Preliminary Ecological Inventory (PEI) for the PCSR.
Fish and Wildlife Coordination Act [40 CFR Part 302]	Requires that the Fish and Wildlife Services (USFWS), National Marine Fisheries Service (NMFS), and related State agencies be consulted when a Federal department or agency proposes or authorizes any control or structural modification of any stream or other water body. Also requires adequate provision for protection of fish and wildlife resources.	Should a remedial alternative involve the alteration of a stream or other body of water, the USFWS, NMFS, and other related agencies must be consulted before that body of water is altered. If the body of water requiring alteration is onsite, then consultation with these agencies is recommended. Consultation with these agencies may be warranted during remedial activities if habitat at OU 1 requires alteration.
Floodplain Management Executive Order No. 11968 [40 CFR Part 6]	Requires Federal agencies to evaluate the potential effects of adverse impacts to floodplains associated with direct and indirect development of a floodplain.	Alternatives that involve modification or construction within a floodplain may not be selected unless a determination is made that no other practicable alternative exists. If no other practicable alternative exists, potential harm must be minimized and action taken to restore and preserve the natural and beneficial values of the floodplain.
National Environmental Protection Act (NEPA) [40 CFR Part 6]	Requires that Federal agencies minimize the degradation, loss, or destruction of wetlands, and preserve and enhance natural and beneficial values of wetlands and floodplains under Executive Orders 11990 and 11988.	During the FS process, identification and evaluation of alternatives involving excavation, transport, or backfilling, in or adjacent to a wetland should address the alternative's impact on the wetland as it relates to NEPA. Wetlands have been identified at OU 1 during the PEI for the PCSR.
Protection of Wetlands Executive Order No. 11990 [40 CFR Part 6]	Requires Federal agencies to avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practical alternative exists.	Alternatives that involve the alteration of a wetland may not be selected unless a determination is made that no other practicable alternative exists. If no other practicable alternative exists, potential harm must be minimized and action taken to restore and preserve the natural and beneficial values of the wetland. Wetlands have been identified at OU 1 during the PEI for the PCSR.
Chapter 17-611, FAC, Florida Wetlands Application Regulations, November 1989	Sets requirements for discharge of domestic wastewater to wetlands.	This rule addresses the discharge of domestic wastewater to wetlands. The discharge limits established are for CBOD, TSS, nitrogen, and phosphorus. This rule may be a TBC for remedial alternatives that would result in discharges to wetlands where these limits may be approached. This rule may be appropriate if extracted groundwater were discharged to wetlands at the OU.

Notes: ARAR = applicable or relevant and appropriate requirement. PCSR = Preliminary Characterization and Screening Report.
RI/FS = Remedial Investigation and Feasibility Study. TSS = total suspended solids.
CFR = Code of Federal Regulations. CBOD = carbonaceous biological oxygen demand.
TBC = to be considered.

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3.2 CHEMICAL-SPECIFIC ARARs. Chemical-specific requirements are usually health- or risk-based standards that limit the concentration of a chemical found in or discharged to the environment. They govern the extent of site remediation by providing either actual cleanup levels or the basis for calculating such levels. Chemical-specific ARARs for the site may also be used to indicate acceptable levels of discharge in determining treatment and disposal requirements and to assess the effectiveness of future remedial alternatives. Table 3-2 presents the chemical-specific ARARs for an interim action to address CPS at OU 1.

3.3 ACTION-SPECIFIC ARARs. Action-specific requirements are technology- or activity-based limitations controlling activities for remedial action. Action-specific ARARs generally set performance or design standards, controls, or restrictions on particular types of activities. To develop technically feasible alternatives, applicable performance or design standards must be considered during the development and screening of alternatives.

Certain action-specific ARARs include permit requirements. However, under CERCLA Section 121(e), permits are not required for remedial actions conducted entirely onsite at Superfund sites. This permit exemption applies to all administrative requirements including: approval of or consultation with administrative bodies, documentation, recordkeeping, and enforcement. However, the substantive requirements of ARARs must be attained. Table 3-3 presents the action-specific ARARs for groundwater remediation at OU 1.

Table 3-2
Synopsis of Potential Federal and State Chemical-Specific ARARs

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Federal Standards and Requirements	Requirements Synopsis	Consideration in the Remedial Response Process
Clean Water Act (CWA), Ambient Water Quality Criteria (AWQC) [40 CFR Part 131]	Sets criteria for surface water quality for the protection of human health and aquatic life. Human health criteria are established for exposure routes involving dermal contact or ingestion of water and consumption of aquatic organisms.	The AWQC criteria are used as guidelines for surface water and include criteria for the protection of marine and freshwater aquatic organisms and consumption of fish.
Safe Drinking Water Act (SDWA), Maximum Contaminant Level Goals (MCLGs) [40 CFR Part 141]	Establishes drinking water quality goals at levels of no known or anticipated adverse health effects with an adequate margin of safety. These criteria do not consider treatment feasibility or cost elements.	MCLGs greater than zero are relevant and appropriate standards for groundwater or surface water that are current or potential sources of drinking water. If groundwater were extracted and required treatment during the remedial activity, this rule may apply.
SDWA National Primary Drinking Water Standards, Maximum Contaminant Levels (MCLs) [40 CFR Part 141]	Establishes enforceable standards for specific contaminants that have been determined to adversely affect human health. These standards, MCLs, are protective of human health for individual chemicals and are developed using MCLGs, available treatment technologies, and cost data.	MCLs established by the SDWA are relevant and appropriate standards where the MCLGs are either zero or not ARARs. MCLs apply to groundwater or surface water that are current or potential drinking water sources. If groundwater were extracted and required treatment during the remedial activity, this rule may apply.
Chapter 17-302, FAC, Florida Surface Water Standards, 1992	Defines classifications of surface waters, and establishes water quality standards (WQS) for surface water within the classifications. The State's antidegradation policy is also established in this rule.	Remedial actions that potentially impact surface waters of the State will consider surface WQS. WQS may also be ARARs for groundwater if no MCL exists and groundwater discharges to surface water and contaminants are affecting aquatic organisms, or other health based standards are not available.
Chapter 17-520, FAC, Florida Water Quality Standards, May 1990	Establishes the groundwater classification system for the State and provides qualitative minimum criteria for groundwater based on the classification.	Drinking water standards are established in Chapter 17-550 of current or potential sources of potable water. The classification system established in this rule defines potable water sources (F-I, G-I, G-II, and G-III waters). The surficial aquifer at OU 1 is classified as G-II groundwater.
Chapter 17-770, FAC, Florida Petroleum Contaminated Site Cleanup Criteria, February 1990	Establishes a cleanup process to be followed at all petroleum contaminated sites. Cleanup levels for G-I and G-II groundwater are provided for both the gasoline and kerosene-mixed LNAPL analytical groups.	This is a potential relevant and appropriate ARAR for petroleum contaminated sites that would discharge to G-I and G-II groundwater. In addition, LNAPL on the water table is defined and discussed in this rule. LNAPL is currently present at OU 1.

Notes: LNAPL = light nonaqueous-phase liquid.
OU = operable unit.
ARARs = Applicable or Relevant and Appropriate Requirements.
PCB = polychlorinated biphenyl.
USEPA = U.S. Environmental Protection Agency.
FAC = Florida Administrative Code.
TBC = to be considered.

Table 3-3
Synopsis of Potential Federal and State Action-Specific ARARs

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Federal Standards and Requirements	Requirements Synopsis	Consideration in the Remedial Response Process
Clean Air Act (CAA), National Ambient Air Quality Standards (NAAQS) [40 CFR Part 50]	Establishes primary (health based) and secondary (welfare based) standards for air quality for carbon monoxide, lead, nitrogen dioxide, particulate matter, ozone, and sulfur oxides.	The attainment and maintenance of primary and secondary standards are required to protect human health and the environment (wildlife, climate, recreation, transportation, and economic values). The principal application of these standards is during remedial activities that may result in exposures through dust and vapors. These standards will be used to assess need for control prior to or during remediation due to unacceptable ambient air levels at OU 1.
CAA, New Source Performance Standards (NSPS) [40 CFR Part 60]	This rule establishes NSPS for specific sources, including incinerators. The NSPSs limit the emissions of a number of different pollutants, including the six criteria pollutants (for which the National Ambient Air Quality Standards [NAAQS] are established) as well as fluorides, sulfuric acid mist, and total reduced sulfur.	NSPS may be applicable if incineration of off gasses is required as a result of aeration type treatment technologies applied at OU 1.
CWA, National Pollutant Discharge Elimination System (NPDES) [40 CFR Parts 122 and 125]	Requires permits specifying the permissible concentration or level of contaminants in the effluent for the discharge of pollutants from any point source into waters of the United States.	Onsite discharge from a CERCLA site to surface waters must meet only the substantive NPDES requirements: administrative permit requirements are waived, consistent with CERCLA section 121(e)(1). Conversely, offsite discharge from a CERCLA site to surface waters must obtain an NPDES permit and meet both the substantive and administrative NPDES requirements. NAS Jacksonville's NPDES permit for water discharge to the St. Johns River has lapsed.
Occupational Safety and Health Act (OSHA), General Industry Standards [29 CFR Part 1910]	Requires establishment of programs to assure worker health and safety at hazardous waste sites, including employee training requirements.	Under 40 CFR 300.38, requirements apply to all response activities under the NCP. During remedial action at the site, these regulations must be maintained.
OSHA, Recordkeeping, Reporting, and Related Regulations [29 CFR Part 1904]	Provides recordkeeping and reporting requirements applicable to remedial activities.	These requirements apply to all site contractors and subcontractors and must be followed during all site work. During remedial action at the site, these regulations must be maintained.
OSHA, Health and Safety Standards [29 CFR Part 1926]	Specifies the type of safety training, equipment, and procedures to be used during site investigation and remediation.	All phases of the remedial response project should be executed in compliance with this regulation. During remedial action at the site, these regulations must be maintained.

See notes at end of table.

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Table 3-3 (Continued)
Synopsis of Potential Federal and State Action-Specific ARARs

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Federal Standards and Requirements	Requirements Synopsis	Consideration in the Remedial Response Process
RCRA, Standards Applicable to Generators of Hazardous Waste [40 CFR Part 262]	Establishes standards for generators of hazardous wastes that address waste accumulation, preparation for shipment, and completion of the uniform hazardous waste manifest. These requirements are integrated with USDOT regulations.	Alternatives that involve offsite transportation of hazardous wastes must be shipped in proper containers that are accurately marked and labeled and the transporter must display proper placards. These rules specify that all hazardous waste shipments must be accompanied by an appropriate manifest. This rule would be an ARAR if RCRA wastes are present or produced during remediation.
RCRA, Preparedness and Prevention [40 CFR Part 264, Subpart C]	Outlines requirements for safety equipment and spill control for hazardous waste facilities. Facilities must be designed, maintained, constructed, and operated to minimize the possibility of an unplanned release that could threaten human health or the environment.	Safety and communication equipment should be incorporated into all aspects of the remedial process and local authorities should be familiarized with site operations if RCRA wastes are present or produced during remediation.
RCRA, Manifest System, Recordkeeping and Reporting [40 CFR Part 264, Subpart E]	Outlines procedures for manifesting hazardous waste for owners and operators of onsite and offsite facilities that treat, store, or dispose of hazardous waste.	Alternatives that involve treatment, storage, or disposal of hazardous waste offsite must attain these rules. For onsite treatment or disposal, these regulations are applicable in order to properly document the disposition of RCRA wastes.
RCRA, Releases from Solid Waste Management Units [40 CFR Part 264, Subpart F]	Establishes the requirements for solid waste management units (SWMUs) at RCRA-regulated treatment, storage, and disposal facilities. The scope of the regulation encompasses groundwater protection standards; concentration limits; point of compliance; compliance period; requirements for groundwater monitoring, detection monitoring, and compliance monitoring; and the corrective action program.	This rule applies to CERCLA sites contaminated with RCRA hazardous constituents, and is applicable for groundwater remediation executed under RCRA Corrective Action Programs. This rule may apply during interim remedial actions at OU 1.
RCRA, Contingency Plan and Emergency Procedures [40 CFR Part 264, Subpart D]	Outlines requirements for emergency procedures to be used following explosions, fires, etc.	These requirements are relevant and appropriate for remedial actions involving the management of hazardous waste. They may apply during implementation of interim remedial actions at OU 1.

See notes at end of table.

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Table 3-3 (Continued)
Synopsis of Potential Federal and State Action-Specific ARARs

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Federal Standards and Requirements	Requirements Synopsis	Consideration in the Remedial Response Process
RCRA, Use and Management of Containers [40 CFR Part 264, Subpart I]	Sets standards for the storage of containers of hazardous waste.	This requirement would apply if a remedial alternative involves the storage of containers of RCRA hazardous waste. Additionally, the staging of study-generated RCRA-wastes should meet the intent of the regulation. These requirements are relevant and appropriate for containerized hazardous waste at CERCLA sites and may apply during interim remedial actions at OU 1.
Federal Facility Compliance Act (FFCA)	Allows state agencies and the USEPA to enforce hazardous waste laws at federal facilities. Provides a conditional exclusion to RCRA's domestic sewage exclusion for federally owned treatment works (FOTWs).	This regulation would apply if a remedial alternative involves the disposal of untreated groundwater into the sanitary sewer system of the base. This requirement prohibits the to introduce into a FOTW any pollutant that is a hazardous waste.
Chapter 17-2, FAC, Florida Air Pollution Rules, September 1990	Establishes permitting requirements for owners or operators of any source that emits any air pollutant. Establishes ambient air quality standards for sulfur dioxide, PM_{10}, carbon monoxide, and ozone.	Establishment of air pollutant cleanup levels should incorporate Florida ambient air quality standards. Where remedial action could result in release of regulated contaminants to the atmosphere, such as may occur during air stripping, this regulation would be a potential ARAR.
Chapter 17-730, FAC, Florida Hazardous Waste Rules, August 1990	Adopts by reference appropriate sections of 40 CFR and establishes minor additions to these regulations concerning the generation, storage, treatment, transportation, and disposal of hazardous wastes.	The substantive permitting requirements for hazardous waste must be met where applicable for CERCLA remedial actions.
Chapter 17-736, FAC, Florida Rules on Hazardous Waste Warning Signs, July 1991	Requires warning signs at NPL and FDEP identified hazardous waste sites to inform the public of the presence of potentially harmful conditions.	This requirement is applicable for sites that are on the NPL or that have been identified by the FDEP as potentially harmful.
Chapter 17-770, FAC, Florida Petroleum Contaminated Site Cleanup Criteria, February 1990	Establishes a cleanup process to be followed at all petroleum contaminated sites. Cleanup levels for G-I and G-II groundwater are provided for both the gasoline and kerosene-mixed product analytical groups.	This is a relevant and appropriate ARAR for petroleum-contaminated sites that would be discharging to G-I and G-II groundwater. In addition, this ARAR defines free product at a site as one where petroleum exists at a thickness in excess of 0.1 inch on the surface water or groundwater.

Notes: CWA = Clean Water Act.
NPL = National Priority List.
USDOT = U.S. Department of Transportation.
CERCLA = Comprehensive Environmental Restoration, Compensation, and Liability Act.
NCP = National Contingency Plan.
RCRA = Resource Conservation and Recovery Act.
FDER = Florida Department of Environmental Regulation.
FDEP = Florida Department of Environmental Protection.
ARAR = applicable or relevant and appropriate requirements.

4.0 IDENTIFICATION OF REMEDIAL ACTION OBJECTIVES

This chapter presents the remedial action objectives (RAOs) for addressing contaminated groundwater at OU 1. RAOs provide the basis for selecting appropriate remedial technologies and developing remedial alternatives for the OU. RAOs are defined in the CERCLA RI/FS Guidance Manual as media-specific goals that are established to protect human health and the environment (USEPA, 1988). RAOs are typically based on contaminant(s) of concern, exposure route(s), and receptors present or available at the site. Additionally, RAOs are developed to ensure compliance with ARARs; these ARARs were identified in Chapter 3.0. Section 4.1 identifies the RAOs for OU 1. Section 4.2 identifies general response actions for each RAO at OU1. Section 4.3 identifies the volume of contaminated groundwater and estimated mass of total VOCs present at the site.

4.1 REMEDIAL ACTION OBJECTIVES.

As outlined in Chapter 2.0, groundwater contamination has been identified at OU 1. Groundwater modeling performed by the USGS indicates that groundwater flows into the stream located to the east of the OU. To mitigate possible migration of contaminated groundwater into this stream the following ROA was established:

RAO 1 Minimize migration of groundwater to prevent possible discharge of contamination to surface water.

Groundwater contamination can be addressed via this focused FS prior to completion of the RI for OU 1. The RI has identified areas in which groundwater contains high concentrations of VOCs. By initiating groundwater treatment at this area, the concentrations of contaminants in groundwater can be reduced prior to completion of the overall FS for OU 1. Therefore, the following RAO was also established for OU 1:

RAO 2 Reduce concentrations of VOCs in groundwater at OU 1.

The effectiveness of any groundwater treatment system implemented as a part of this FFS will be reevaluated in the overall FS for OU 1. At that time, the groundwater treatment system can be refined or eliminated based on operational data collected to date.

In all, the RAOs for this FFS are established for Contaminant Plume Reduction (CPR) and Groundwater Migration Stabilization (GMS) at OU 1. These RAOs are protective of human health and the environment and are consistent with the long-term goals of remediation at OU 1. Also, the RAOs established will not interfere with other RAOs already established for LNAPL recovery at the OU.

4.2 IDENTIFICATION OF GENERAL RESPONSE ACTIONS. General response actions describe potential media-specific measures that may be employed to address RAOs. General response action for groundwater migration stabilization (RAO 1) include:

- Groundwater Flow Containment or
- Groundwater Extraction and *Ex-situ* Treatment.

General response actions for contaminant plume reduction (RAO 2) include:

- *In-situ* Treatment.

Check these calculations.

I get 5093 Kg for mass of contaminants

AND I DON'T NECESSARILY agree w/ volume calculation.

Technologies addressing each o ... included in Chapter 5.0.

4.3 IDENTIFICATION OF VOLUME ... f the volume of contaminated groundwater at ... Approximate dimensions of the plume are 3 ... ridth, and an average depth of 25 feet (with ... approximately 700 million gallons (see Figu...

A preliminary estimate of the ... ter at OU1 is included in Appendix E. Ass... 000 ug/l, and total volume of 700 million ga... aqueous phase at OU1 is estimated as 12,00... ertical cross section of the plume in a d... lines at two different time frames).

5.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

The purpose of this chapter is as follows:

- to identify and screen appropriate technologies for each general response action,

- assemble technologies into alternatives to address each of the RAOs developed in Chapter 4.0: groundwater migration stabilization and VOC contaminant mass reduction at OU 1, and

- screen the technologies and assemble appropriate remedial alternatives corresponding to RAO 1 and RAO 2 and develop OU specific alternatives.

Section 5.1 summarizes the technology screening for each general response action for this interim action and Section 5.2 present and develops remedial alternatives for OU 1. Figure 5-1 presents the summary of Alternative Development Process for OU1 groundwater.

5.1 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES. Technologies to address groundwater migration stabilization and contaminant reduction at OU 1 were identified based upon a review of current literature, vendor information, and experience in developing remedial alternatives for similar sites and conditions. Technologies were also identified using site- and waste-specific characteristics. Site characteristics considered during technology development included the following:

- site geology, hydrology, and terrain;

- availability of space and resources necessary to implement a given technology; and

- presence of special site features (e.g., sensitive ecological environments, endangered species, and land use).

Figure 5-1 Development of Alternatives for OU 1, Groundwater

The following waste characteristics were also considered:

- contaminated media;
- type and concentrations of waste constituents; and
- physical and chemical properties of the waste (e.g., volatility, specific weight, viscosity, and flammability).

Table 5-1 presents remedial technologies applicable for addressing each general response action included in Chapter 4.0. This table also presents the screening of those technologies. The technology screening process reduces the number of potentially applicable technologies by evaluating the advantages and disadvantages of each technology. Technologies deemed ineffective or not implementable were eliminated from further consideration. The remaining technologies are assembled into alternatives addressing each RAO in Section 5.2.

5.2 DEVELOPMENT OF ALTERNATIVES. Remedial technologies that passed the technology screening phase were assembled into alternatives that address contaminated groundwater, that meet the remedial action objectives set forth in Chapter 4.0. A limited number of alternatives were developed for this FFS because of the focused nature of the study.

The technologies that pass the screening step were assembled into four alternatives that address remedial action objectives for contaminated groundwater at OU 1 (Table 5-2). A no-action alternative is not considered for this FFS because the intent of the FFS is to address groundwater contamination at OU 1 via removal of VOCs; the no action alternative is inconsistent with this goal.

The alternatives are evaluated against the RAOs based on cost, effectiveness, and implementability. A brief summary of this screening step is presented on Table 5-3. RAO 1 would be achieved by either Alternative A or B. RAO 2 would be achieved by either Alternative C or D.

Table 5-1
Identification and Screening of Applicable Remedial Technologies for General Response Actions at OU 1

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

General Response Action or Technology	Description of Technology	Advantages	Disadvantages	Screening Status
No Action				
Groundwater Monitoring	Perform water quality analyses to monitor contaminant migration and assess future environmental impacts.		• Implementation of technology does not contribute to site remediation.	Eliminated. Does not meet remedial action objectives (RAOs); technology will be reevaluated for applicability during the overall Feasibility Study (FS) for OU 1.
Containment				
Subsurface Slurry Wall	Emp abili wat		vould not reduce mass of contam- t in groundwater. on of technology ctively contain i groundwater.	Eliminated. Implementation of technology does not meet the RAOs for this Focused FS.
Collection				
Interceptor Trenches	Ir c		of trenches may be cause of wooded ecovery techniques nave a greater ion time frame than n wells. ed soils must be man- opropriately.	Retained. Technology was discussed and retained in the Focused FS for light non-aqueous phase liquid (LNAPL) recovery. Trenches would serve a dual purpose: LNAPL recovery and groundwater collection.
Extraction Wells	Installation of several strategically located pumping wells to collect contaminated groundwater for treatment.	• Has been successfully implemented at other CERCLA sites.	• Effectiveness of pumping decreases in fine grained soils.	Retained. Use of extraction wells at OU 1 would assist in the collection of pump test data and help refine existing groundwater models.

WHAT ABOUT HORIZONTAL WELLS

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Table 5-1 (Continued)
Identification and Screening of Applicable Remedial Technologies for General Response Actions at OU 1

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

General Response Action or Technology	Description of Technology	Advantages	Disadvantages	Screening Status
Treatment				
Ultraviolet (UV)/Oxidation	Use of UV light and chemical oxidants (e.g., hydrogen peroxide (H_2O_2) or ozone (O_3) to degrade organic contaminants in water. Byproducts of oxidation are carbon dioxide, water, and chloride.	• Has been successfully implemented at other CERCLA sites. • Provides permanent destruction of organics into carbon dioxide and water • UV systems in combination with H_2O_2 produce no vapor emissions or byproducts requiring disposal.	• Capital intensive technology. • System reliability is dependent on the water quality parameters such as turbidity, total suspended solids and concentrations of iron and manganese.	Retained. Proven technology for treatment of volatile organic compounds (VOCs) in groundwater.
Air Stripping	Removal of volatile compounds from groundwater by passing air through the contaminated liquid. Contaminants are transferred to the gaseous phase.	• Has been successfully implemented at other CERCLA sites. • Treatment would reduce toxicity of chemical in groundwater. • Technology can be implemented without pilot tests.	• Pretreatment for removal of inorganics may be necessary to prevent fouling of air stripper system. • Technology does not destroy contaminant but transfers contaminant to the vapor phase. • Off-gases produced during remediation would require collection, treatment, and disposal. • Post-treatment by carbon adsorption may be required to meet discharge requirements.	Retained. Proven technology for treatment of VOCs in groundwater.

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Table 5-1 (Continued)
Identification and Screening of Applicable Remedial Technologies for General Response Actions at OU 1

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

General Response Action or Technology	Description of Technology	Advantages	Disadvantages	Screening Status
Carbon Adsorption	Reduces concentrations of aqueous or gaseous phase organics through adsorption onto granular carbon particles.	• Liquid phase carbon adsorption is a well established technology. Has been successfully implemented at other CERCLA sites. • Technology effectively removes organic material from groundwater by sorption. • Operation of technology is simple. • Capital costs tend to be lower than for UV/Oxidation.	• Suspended solids may require removal prior to treatment to avoid clogging of carbon bed. • Carbon adsorption could be implemented as a polishing step for air stripping to meet discharge requirements. • Spent carbon from the adsorption process would require regeneration.	Retained. Proven technology for treatment of VOCs in groundwater.
Wet Air Oxidation	Destroys organic contaminants in aqueous solution by inducing oxidation and hydrolysis at high temperature and pressure conditions.	• Treatment process produces no air emissions or sludge.	• Technology has been used extensively in industry, but utilization of this technology for CERCLA sites is limited.	Eliminated.
Thin Film Evaporation	Remove contaminants in from extracted groundwater by vaporizing water from contaminants.	• Organic compounds can be recovered from viscous liquids.	• Technology produces a concentrated wastestream requiring further treatment. • Energy source required for evaporation process.	Eliminated.
Reverse Osmosis	Remove organics from extracted groundwater using membrane process. At high pressures, membrane allows water to pass through the membrane while organics are retained.	• Technology is well developed. • RO units could be used in series or in parallel to provide flexibility in dealing with increasing flow rates of concentrations of dissolved compounds.	• Process produces concentrated wastestream requiring further treatment. • Requires extensive pretreatment to remove particulates, organic matter and oxidizing salts.	Eliminated.

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Table 5-1 (Continued)
Identification and Screening of Applicable Remedial Technologies for General Response Actions at OU 1

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

General Response Action or Technology	Description of Technology	Advantages	Disadvantages	Screening Status
Biological Treatment	Destroys organics through biodegradation, acclimation-degradation, or chemical conversion of the organic wastes by introducing the extracted groundwater to either an aerobic or anaerobic biological treatment process.	• Reduces toxicity of waste stream through conversion of organics into biomass. • Mobile units are available. • Traditional technology with well defined design parameters.	• Chlorinated organics may be difficult to treat. • Treatment process produces a sludge that requires collection, treatment, and disposal.	Eliminated.
Air Sparging with Soil Vapor Extraction (SVE)	Air is injected into saturated zones for the purpose of stripping VOCs by volatilization. Air sparging is used in conjunction with vadose zone, SVE.	. Has been successfully implemented at other CERCLA sites. . Treatment would reduce toxicity of chemical in groundwater.	. Air movement within the saturated zone is difficult to monitor. . Potential for biodegradation would result in break down of chlorinated compounds into harmful and more toxic compounds. Requires pilot scale studies before implementation.	Retained.
Discharge				
Facility Owned Treatment Works (FOTW)	Disposal of groundwater to the Naval Air Station (NAS) Jacksonville wastewater treatment plant.	• If sewer connection nearby, this can be a relatively inexpensive discharge option.	• Approval by community, Florida Department of Environmental Protection (FDEP), and U.S. Environmental Protection Agency (USEPA) required.	Retained. FOTW present and accessible at NAS Jacksonville.
Surface Water	Disposal of groundwater to a nearby surface water body.	• Stream is located nearby.	• National Pollution Discharge Elimination System (NPDES) permit required.	Retained.

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Table 5-2
Identification and Screening of Applicable Technologies and Processes

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Alternative	Collection	Treatment: UV/ Oxidation	Treatment: Air Stripping	Treatment: Carbon Adsorption	Treatment: Air Sparging and SVE	Discharge to FOTW
Alternative A	X	X				X
Alternative B	X		X	X		X
Alternative C	(In-situ)		X			
Alternative D	(In-situ)				X	

Notes: UV = ultraviolet.
SVE = soil vapor extraction.
FOTW = facility owned treatment works.

Table 5-3
Screening of Remedial Alternatives against RAOs

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Alternative Option	Description	Screening Rationale: RAO 1 - Groundwater Migration Stabilization	Screening Rationale: RAO 2 - Contaminant Plume Reduction	Status
Alternative A: Collection, Ultraviolet (UV)/ Oxidation, Discharge	Alternative would involve the installation of an extraction system and treatment of groundwater via UV/Oxidation. Treatment provides permanent destruction of volatile organic compounds (VOCs). Treated water would be discharged to the facility owned treatment works (FOTW) or the nearby stream. Treatment effectiveness and cost will be compared to Air Stripping and Carbon Adsorption.	Would meet the remedial action objectives (RAO). Groundwater extraction results in control of migration of groundwater near the surface water stream. Rate of extraction of groundwater may be controlled to optimum flow rates to meet the objective.	Would achieve the RAO. But pump and treat equipment would be located near the housing area and may cause potential health effects.	Retained for RAO 1.
Alternative B: Collection, Air Stripping, Carbon Adsorption, Discharge	Alternative would involve the installation of an extraction system and treatment of groundwater via air stripping followed by polishing by carbon adsorption. Treatment would provide a reduction in toxicity, mobility, and mass of contaminants. Off-gas from the air stripper would require further treatment and carbon would require regeneration. Treated water would be discharged to the FOTW or the nearby stream. Treatment effectiveness and cost will be compared to UV/Oxidation.	Analysis is same as for Alternative A.	Analysis is same as for Alternative A.	Retained for RAO 1.
Alternative C: In-situ Air Stripping	Alternative would involve the installation of vertical circulation wells with in-situ treatment via air stripping. Treatment would provide a reduction in toxicity, mobility, and mass of contaminants in groundwater. Off-gas from the air stripper would require further treatment. Treatment effectiveness and cost will be compared to extraction alternatives and in-situ air sparging.	Migration control is not achieved as sufficiently with in-situ treatment as with pump and treat.	Would meet RAO.	Retained for RAO 2.
Alternative D: In-situ Air Sparging	Alternative would involve the installation of wells with in-situ treatment via air sparging. Treatment would provide a reduction in toxicity, mobility, and mass of contaminants in groundwater. Off-gas from the system would require further treatment. Treatment effectiveness and cost will be compared to extraction alternatives and in-situ air stripping.	Analysis is same as for Alternative C.	Analysis is same as for Alternative C.	Retained for RAO 2.

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Alternatives that meet RAO 1 are combined with those that meet RAO 2 resulting in OU specific Alternatives that meets both the RAOs.

Thus Alternatives A or B is combined with either Alternatives C or D resulting in four sets of alternatives. Table 5-4 presents the development of OU specific alternatives. Table 5-5 presents detailed description of OU specific alternatives.

These four alternatives are described in detail in Chapter 6.0. The detailed analysis of these alternatives against the technical criteria is also presented in Chapter 6.0.

Table 5-4
Development of OU Specific Alternatives

Focused RI/FS for Contaminant Plume Stabilization
Operable Unit 1, NAS Jacksonville

Alternative for Detailed Analysis	Alternatives for RAO 1						Alternatives for RAO 2		
	Collection	UV/ Oxidation	Air Stripping	Carbon Adsorption	FOTW Discharge		In-Situ Air Stripping via Vertical Circulation Well	In-Situ Air Sparging with SVE	
Alternative 1	X	X			x	(A)	x		(C)
Alternative 2	x		x	x	x	(B)	x		(C)
Alternative 3	x	x			x	(A)		x	(D)
Alternative 4	x		x	x	x	(B)		x	(D)

Table 5-5
Summary of OU Specific Alternatives

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Alternative for Detailed Analysis	Alternative for RAO 1	Alternative for RAO 2
Alternative 1	Alternative A: Collection, UV/oxidation, FOTW Discharge	Alternative C: *In-situ* Air Stripping via vertical circulation well.
Alternative 2	Alternative B: Collection, Air Stripping, GAC adsorption, FOTW Discharge	Alternative C: *In-situ* Air Stripping via vertical circulation well.
Alternative 3	Alternative A: Collection, UV/oxidation, FOTW Discharge	Alternative D: *In-situ* Air Sparging with SVE
Alternative 4	Alternative B: Collection, Air Stripping, GAC adsorption, FOTW Discharge	Alternative D: *In-situ* Air Sparging with SVE

Notes: RAO = remedial action objectives.
UV = ultraviolet.
FOTW = facility owned treatment works.
GAC = granular activated carbon.
SVE = soil vapor extraction.

6.0 DETAILED ANALYSIS OF ALTERNATIVES

The remedial alternatives for addressing groundwater migration stabilization and contaminant plume reduction at OU 1 are evaluated in detail in this chapter. This detailed evaluation of each remedial alternative includes the following:

- a detailed description of the remedial alternative emphasizing the application of the technology, and

- a detailed analysis of the remedial alternative against seven of the nine criteria outlined in CERCLA Section 121(b).

The remedial alternatives are examined with respect to the requirements stipulated in CERCLA and factors described in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988). The nine technical criteria from the RI/FS guidance are:

- overall protection of human health and the environment;
- compliance with ARARs;
- long-term effectiveness and permanence;
- reduction of mobility, toxicity, or volume;
- short-term effectiveness;
- implementability;
- cost;
- State acceptance; and
- community acceptance.

Typically, the State acceptance criterion is not addressed until comments on the RI/FS have been received from the State. Similarly, the community acceptance addressed upon receipt of public comments on the proposed plan (USEPA, 1988). The Responsiveness Summary and the Interim Record of Decision (IROD) will address and incorporate, state and community comments thus addressing the eighth and ninth criteria. This FFS uses the first seven criteria in the alternative evaluation process.

CERCLA section 121(c) requires that any site where a remedial action that results in hazardous substances, pollutants, or contaminants remaining onsite is implemented, must be reviewed at least every 5 years. This requirement will be addressed during the overall FS for OU 1 at NAS Jacksonville.

Following the detailed analysis of each technology comprising the alternatives, the information was summarized for each alternative. This summary, presented in Chapter 7.0, enables comparative analysis of the remedial alternatives.

<u>6.1 ALTERNATIVE 1, *EX-SITU* TREATMENT VIA UV/OXIDATION; AND *IN-SITU* AIR STRIPPING VIA VERTICAL CIRCULATION WELL</u>. This alternative consists of the implementation of technologies to achieve the RAOs, established in Chapter 4.0. RAO 1 would be achieved through collection and *ex-situ* treatment of groundwater via UV/oxidation with offsite discharge of effluent to FOTW; and RAO 2 would be achieved through treatment of groundwater by *in-situ* air stripping via vertical circulation well.

The following subsections provide a description of the principles upon which each of the technologies are based, methods for managing waste streams produced through treatment, factors affecting the cost and performance of each of the technologies, and the operational logistics for implementing the alternative.

A site layout for this alternative is presented in Figure 6-1.

<u>6.1.1 Collection and *Ex-situ* Treatment via UV/oxidation, with Offsite Discharge</u>

<u>Description</u>. This alternative would consist of the installation of a network of extraction wells to extract groundwater and stabilize the migration. Extracted groundwater would be pumped to an equalization tank located on site for subsequent feed into the treatment unit. Effluent from the treatment unit would be followed by the discharge to the FOTW.

The major activities associated with this alternative include the following:

- site clearing and preparation,
- installation of extraction system,

Figure 6-1 Site Lay-Out for Alternative 1

- installation of UV/oxidation system,
- installation of piping network to the FOTW,
- start-up of the extraction system and treatment unit, and
- operation and maintenance.

A process flow diagram for this alternative is provided in Figure 6-2.

Site Clearing and Preparation. Site clearing and preparation would include all activities or construction necessary prior to installation of a groundwater treatment system at the OU. These activities would include:

- construction of bermed concrete pads for staging of the extraction system and off-gas treatment unit, and

- installation of a compound around the equipment with clearing and grubbing of trees that may interfere with the installation of the treatment system, piping, or any other units.

Clearing and grubbing of ground cover, stumps, and trees at the OU would be minimal but may be necessary prior to construction of this alternative. Construction permits, work permits, and site clearance would be obtained prior to beginning intrusive work at OU 1. All underground utilities would be located and staked.

Installation of Extraction System. This subsection describes the preliminary designs and evaluates extraction system for the groundwater migration stabilization at OU 1.

The general approach to developing a groundwater migration stabilization system for OU 1 groundwater was to design a network of wells, strategically placed, at the downgradient edge of groundwater contamination that would reduce further migration of the contaminated groundwater at the OU. These wells would be used to manage migration of the plume. Figure 6-1 shows potential location of the three groundwater extraction wells.

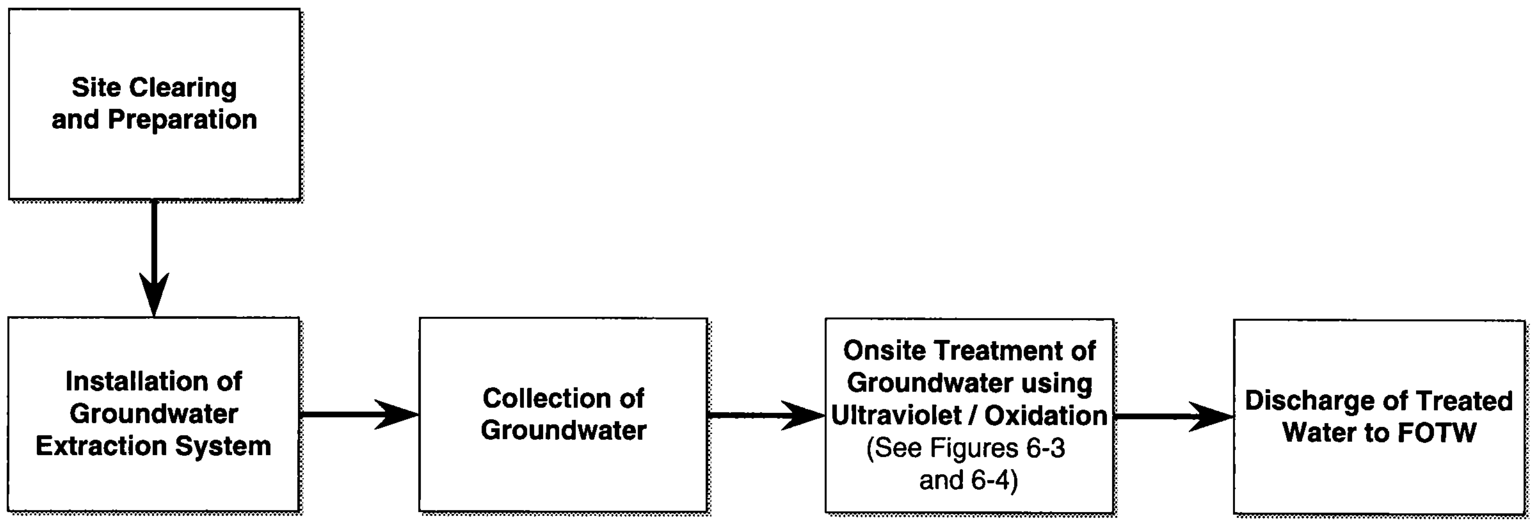

FIGURE 6-2

FLOW PROCESS DIAGRAM FOR ALTERNATIVE 1,
EX-SITU TREATMENT VIA ULTRAVIOLET / OXIDATION

FOCUSED RI/FS
CONTAMINANT PLUME
REDUCTION AT OU 1

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This approach minimizes the extraction of uncontaminated groundwater adjacent to and surrounding the plume. In order to design an effective extraction well system, the entire plume area should be captured within the radius of influence (Def) of the extraction wells.

As discussed in Chapter 4.0 the dimensions of the plume are approximately 3,000 feet long, 2,500 feet wide, and 25 feet thick; it is located to a maximum depth of approximately 40 feet at the downgradient edge. The cross-sectional area (i.e, 2,500 feet by 25 feet) was the target capture area for the extraction system.

For the purpose of this analysis, three extraction wells and a flow of 15 to 25 gpm were used. The pumping rate is a conservative value based on data from the RI and preliminary modeling completed by the USGS (see Chapter 2.0). Each well would be 6 inches in diameter and would be screened at a total depth of 30 to 45 feet bls. Screen intervals would be 10 feet.

Implementation of the alternative would address some data gaps identified in Chapter 2.0.

Once the extraction wells are installed, pumps would be installed. Each well would have a dedicated pump and the effluent piping would be connected via manifold to the pump and directed to a tank. Tank-full shut-off valves would be installed to prevent spillage from overflow. The tank and associated controls would be placed on the bermed concrete pad. The tank would also serve as a equalization basin for the flow rates.

<u>Installation of UV/Oxidation Unit</u>. The ultraviolet (UV)/oxidation technology destroys organic compounds in groundwater through chemical oxidation enhanced by exposure to UV light. Reagents used with UV/oxidation include hydrogen peroxide (H_2O_2) or ozone (O_3). In the oxidation process, hydrocarbons are broken down into carbon dioxide and water. Halogens (e.g., chlorine) are converted to halides (e.g., chloride).

UV/oxidation occurs in a stainless steel chamber containing vertically or horizontally mounted UV lamps. The chamber contains baffles to facilitate UV radiation contact with the influent stream and maximize contact of contaminated groundwater with UV light. The process is the same for either oxidant (i.e., H_2O_2, or O_3); however, the manner in which the oxidant is introduced into the waste stream differs. If H_2O_2 is used, it is metered in water solution into the waste stream prior to entering the reactor; whereas O_3, generated onsite, is diffused as a gas directly into each baffle. UV/O_3 systems are equipped with a catalytic destructor for destroying residual O_3 prior to release of the gas to atmosphere. Figures 6-3 and 6-4 present the schematic of UV/oxidation system using H_2O_2, and 03 respectively.

UV/oxidation is expected to achieve more than 99 percent destruction efficiency for chlorinated compounds in groundwater.

Piping to FOTW. The FOTW currently operates at less than 40 percent of the design hydraulic capacity (see Appendix F, daily logs of FOTW). The current treatment system consists of a primary, secondary, and tertiary treatment units with discharge to a surface water body (St. Johns River located North-North East of the base). The Navy proposes discharging effluent from the UV/oxidation system to the FOTW for reasons including: (1) the FOTW is operating well below its design hydraulic capacity, (2) the effluent from the treatment system will meet all the influent pretreatment requirements of the FOTW, and (3) the influent will not cause interference with the FOTW treatment systems or pass through of contaminants to the effluent.

Start-up of Extraction System. Once the extraction pumps and the associated appurtenances are installed, groundwater extraction would be initiated. Pump settings and collection rates would be adjusted to obtain a flow rate of approximately 5 gpm from each pump. A total of three pumps will be used to extract the groundwater to achieve groundwater migration stabilization.

Operation and Maintenance. Table 6-1 includes the factors affecting the Operation and the required maintenance for this technology.

6.1.2 *In-situ* Treatment via Air Stripping by Vertical Circulation Well *In-situ* air stripping via vertical circulation well involves the installation of a groundwater well with screens at two different intervals. Figure 6-5 presents the schematic of the vertical circulation well for two patterns: standard

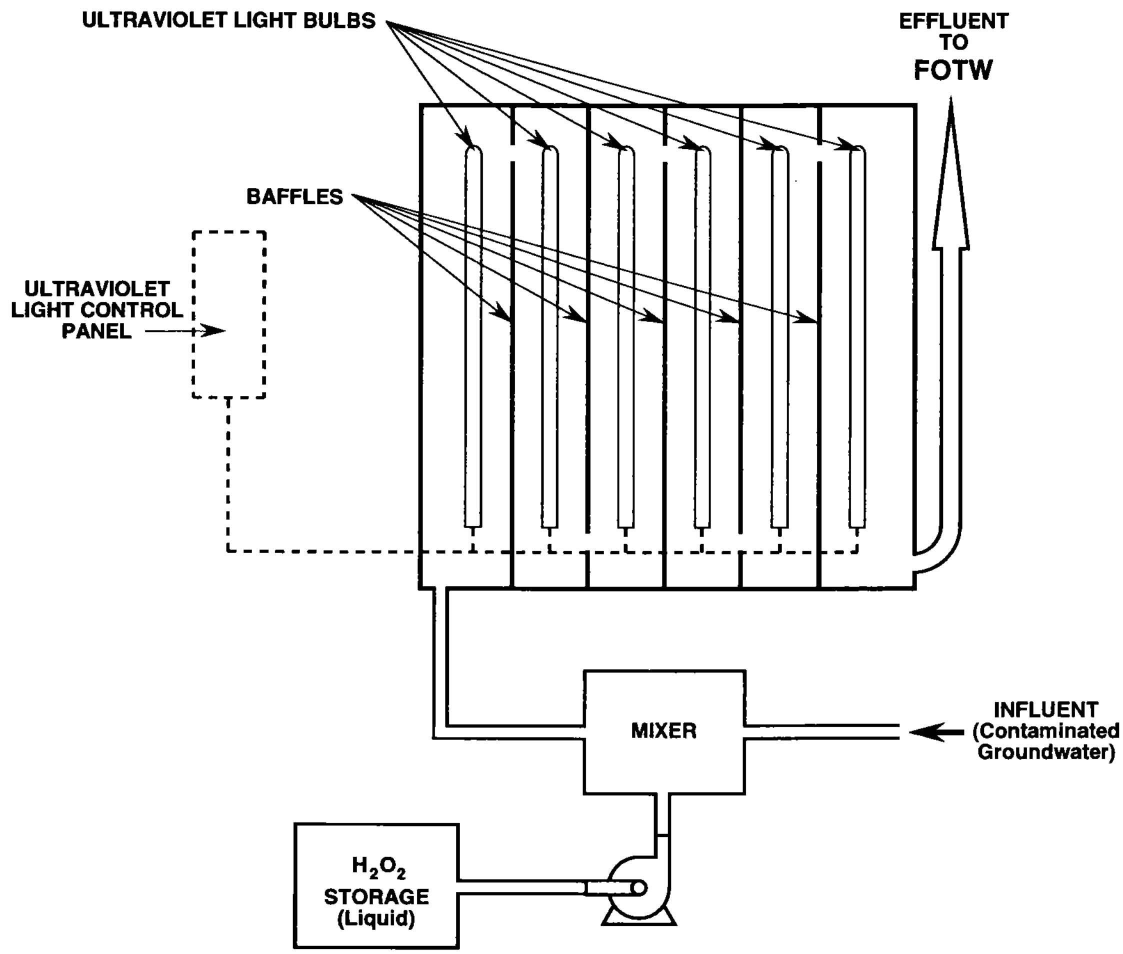

FIGURE 6-3

SCHEMATIC OF ULTRAVIOLET / OXIDATION WITH HYDROGEN PEROXIDE

FOCUSED RI/FS CONTAMINANT PLUME REDUCTION AT OU 1

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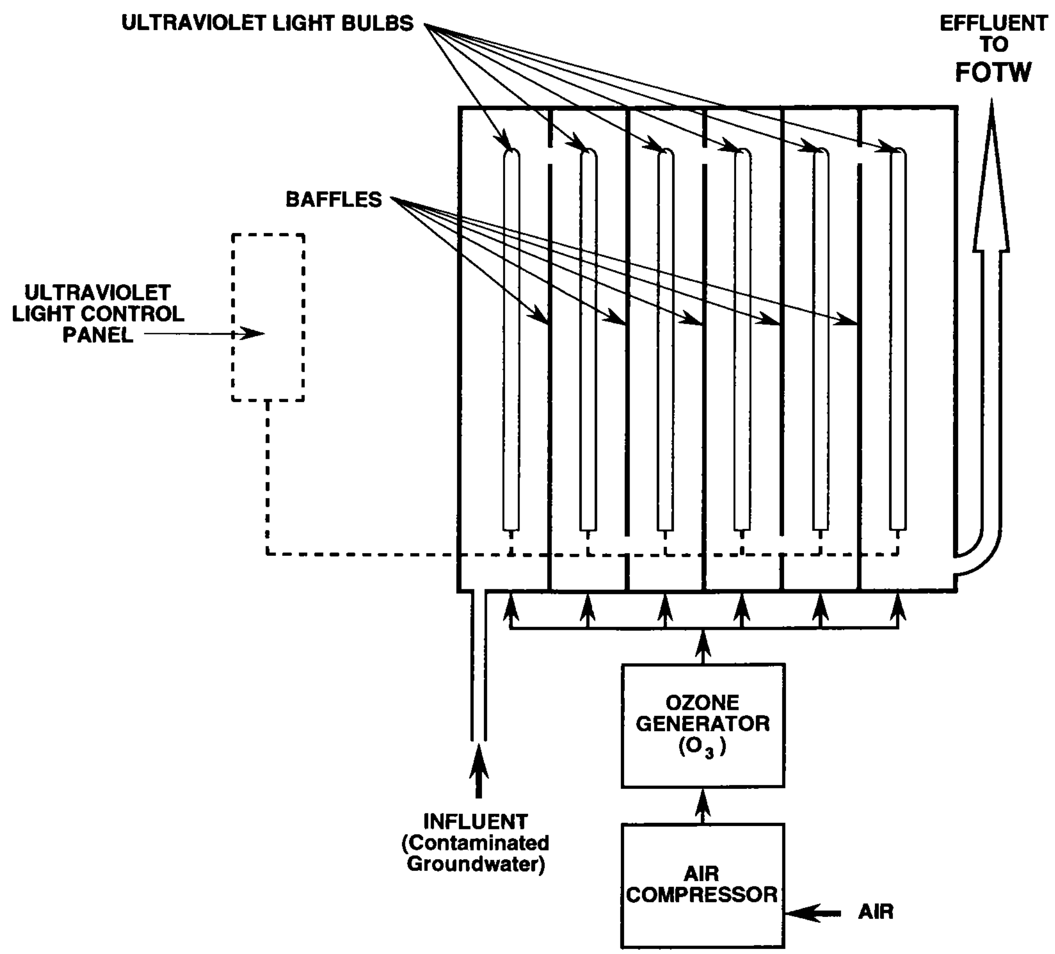

FIGURE 6-4

SCHEMATIC OF ULTRAVIOLET / OXIDATION WITH OZONE

FOCUSED RI/FS
CONTAMINANT PLUME
REDUCTION AT OU 1

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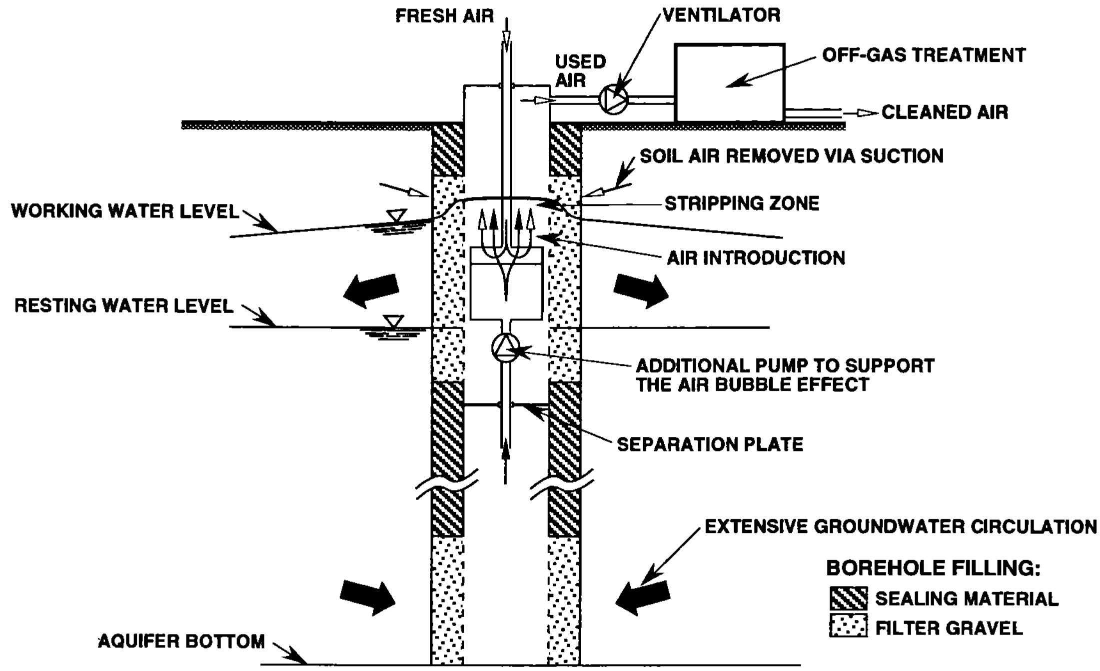
Table 6-1
Factors Affecting Operation and Maintenance for Alternative 1

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

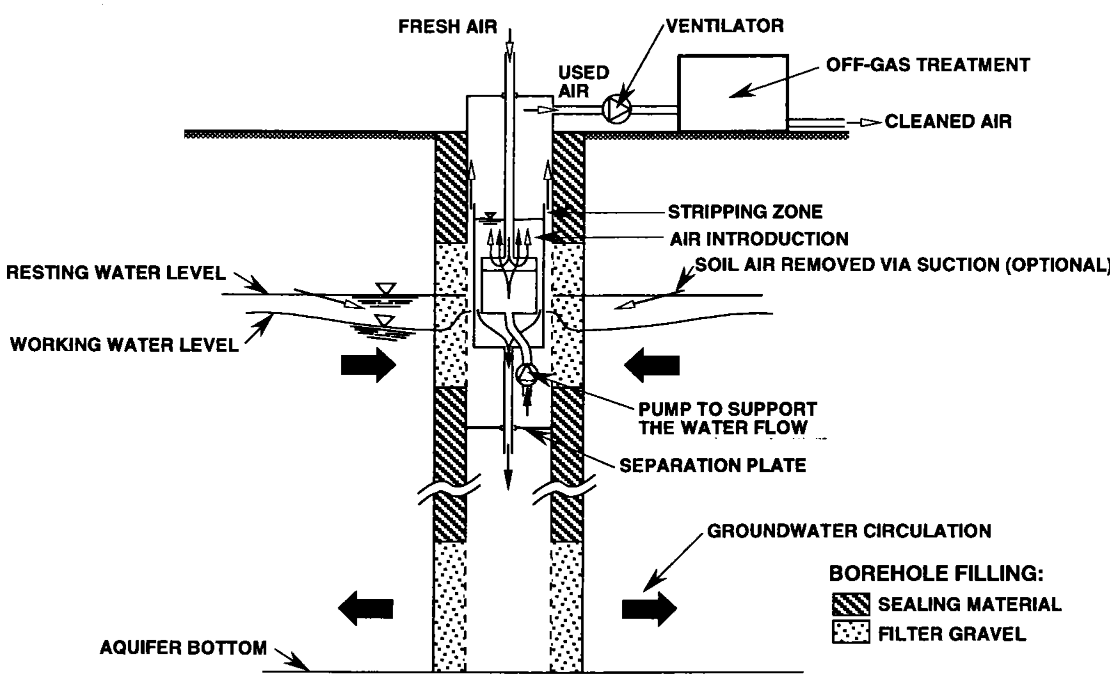
ALTERNATIVE 1. Collection and Treatment via UV/Oxidation, Discharge to FOTW; In-situ Treatment via Air Stripping by Vertical Circulation Well.

	Operation	Maintenance
Extraction System	• Extraction pump flow rates	Extraction pump and associated units
UV/Oxidation	• Influent flow control	Flow equalization tank and associated manifold
	• Influent Water Quality Monitoring	
	• Influent water pH, turbidity control	
	• UV light energy monitoring and control	Cleaning of lamps and sleeve
	• H_2O_2 or O_3 dosage control	H_2O_2 or O_3 containers and associated safety valves
	• Air quality monitoring	Air quality monitoring equipment
FOTW Discharge	• Discharge rates	Piping and lift pumps
	• Effluent water quality monitoring and control	
In-situ Air Stripping via Vertical Circulation Well	• Extraction, and injection flow rates in the vertical circulation wells	Pumps, blowers, well screens and associated appurtenances
	• Off-gas collection, and flow monitoring	
	• Influent off-gas quality monitoring	
	• Effluent off-gas quality control	Temperature, humidity, of vapor phase adsorption beds
	• Air quality monitoring	Air quality monitoring equipment

Notes: UV = ultraviolet.
H_2O_2 = hydrogen peroxide.
O_3 = ozone.
FOTW = facility owned treatment works.



STANDARD CIRCULATION



REVERSE CIRCULATION

SOURCE: IEG TECHNOLOGIES CO., CHARLETTE, N.C.

FIGURE 6-~~6~~ 5 SCHEMATIC OF VERTICAL CIRCULATION WELL WITH IN-SITU AIR STRIPPER	FOCUSED RI/FS CONTAMINANT PLUME REDUCTION AT OU 1 NAS JACKSONVILLE, JACKSONVILLE, FLORIDA

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circulation, where water enters at the bottom screen and leaves at the top screen; and reverse circulation, where WATER wter enters the well at the top and leaves at the bottom. Main components of vertical circulation well are as follows:

1. screens at two different intervals,
2. mobile separation plate,
3. compressor to supply fresh air,
4. blower to ventilate the used a~~re~~ir (contaminated air),
5. off-gas treatment unit, and
6. additional pump to support air bu~~lle~~bble effect.

Vertical circulation process involes injecting gas, usually air, into the well, resulting in an in-well airlift pump effect. The purpose is to decrease pressure in the deeper portions of the well and to increase pressure in the upper portion. This pressure change results in groundwater flow out of the well into the well at the bottom and flow out of the well in the upper portion. The air stream also serves to "strip" the volatiles, from the contaminated groundwater. The pressure difference results in a circulation pattern established in the aquifer.

The upper closed portion of the well is maintained at below atmospheric pressure by a ventilator. This lifts the water level within the well casing about 1 to 2 feet. Air for the stripping process is introduced into the system through fresh air pipe; the upper end is open to the atmosphere, and the lower end terminated in a pinhole plate below the groundwater surface within the well. The height of the pinhole plate is adjusted such that the water pressure is lower there than the atmospheric pressure. Therefore, the fresh air is drawn into the system. The reach between the pinhole plate and the water surface in the well casing is the stripping zone, in which water moves upwards and causes a suction effect at the well bottom (Figure 6-5). The vertical circular flow pattern created within the groundwater around the well provides a continuous contact between the stripping zone and the contaminated groundwater. VOCs in the gaseous phase that have been removed from the contaminated groundwater are collected and treated onsite.

The major activities associated with this treatment include the following:

- site clearing and preparation,
- installation of vertical circulation wells,
- installation of off-gas treatment unit,
- start-up of the *in-situ* groundwater treatment system, and
- operation and maintenance.

Process flow diagram for this alternative is included in Figure 6-6.

Site Clearing and Preparation. Site clearing and preparation would include all activities or construction necessary prior to installation of a groundwater treatment system at the OU. These activities would include:

- construction of bermed concrete pads for staging of the vertical circulation well system and off-gas treatment unit, and

- installation of a compound around the treatment system with clearing and grubbing of trees that may interfere with the installation of the treatment system, piping, or any other units.

Clearing and grubbing of ground cover, stumps, and trees at the OU would be minimal, but may be necessary prior to construction of this alternative. Construction permits, work permits, and site clearance would be obtained prior to beginning intrusive work at OU 1. All underground utilities would be located and staked.

Installation of the Vertical Circulation Wells. This subsection describes in detail the Vertical Circulation Well. at OU 1.

Size of the capture zone for a vertical circulation well is controlled by the well construction details and the flow rates of groundwater through extraction and injection screens. Construction details affecting the width of upgradient capture zone include: total depth of the well, depth below water surface, extraction and injection screen intervals, and separation distance between extraction and

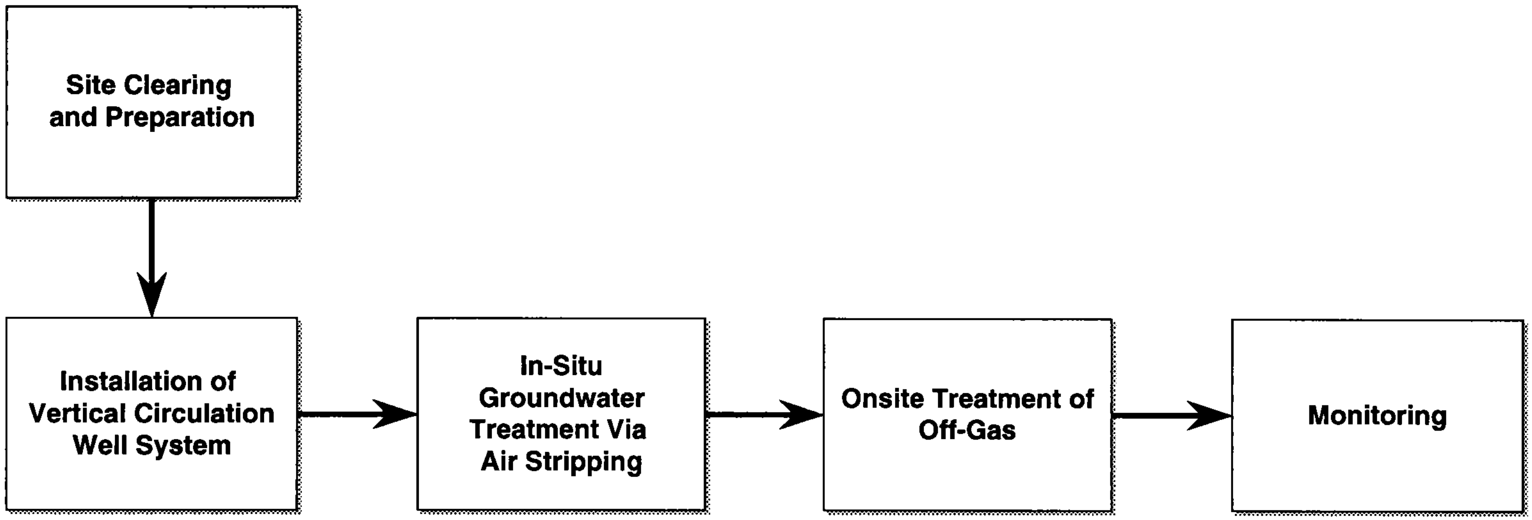

FIGURE 6-~~5~~ 6

FLOW PROCESS DIAGRAM FOR ALTERNATIVE 1, IN-SITU TREATMENT VIA AIR STRIPPING BY VERTICAL CIRCULATION WELL

FOCUSED RI/FS
CONTAMINANT PLUME
REDUCTION AT OU 1

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injection screen intervals (GROUNDWATER, Vol 30, No. 5-September-October 1992, pp 765-773).

A vertical circulation well can be designed and assembled prior to installation at OU 1. Quantity and location of wells to be installed will be determined by the extent of the VOC contaminant plume and the width of the capture zone for each well. Preliminary design calculations (See Appendix A) indicate that using one well at the center of the VOC contamination as presented in Figure 6-2 will be sufficient to achieve RAO established in Chapter 4.0. How ever, for the purpose of this FFS, this preliminary design will include two vertical circulation wells.

The wells will be installed to a total depth of 45 feet bls, with screen intervals of 10 feet each for extraction and injection and a 10 feet separation distance between the extraction and injection screens. Estimated width of the capture zone, based on the preliminary design is 200 feet, and the expected flow rates for extraction and injection are 20 gpm (see Appendix A).

Installation of Off-Gas Treatment Unit. Off-Gas treatment considered for this FFS is performed by using adsorption technology. Adsorption systems utilize granular activated carbon or synthetic resins as adsorbents. The phenomena of adsorption of organic compounds (adsorbate) onto solids is due to electrostatic and covalent interactions between the adsorbate and the solid surface. These interactions include vander walls, dipole-dipole and hydrogen bonding forces. As the solid surface is filled with the adsorbate, the adsorption media requires regeneration. Regeneration can be done onsite or offsite using steam or solvents. Factors affecting the performance of vapor phase adsorption media include: concentrations of contaminants in the off-gas, type of contaminants present , and temperature and humidity of the off-gas. The capability to easily regenerate the adsorbent bed *in-situ* is a key parameter in the process economics for an adsorbent system. The proper regenerant will depend on the solubility of each adsorbate as well as the ease of management handling and disposal of the concentrated contaminant or spent regenerant stream.

Preliminary estimates on the concentrations of off-gas generated and the rate of mass of adsorbent required for this technology are included in Appendix F.

Start-up of *In-situ* Groundwater Treatment System. Once the vertical circulation wells and the associated appurtenances are installed, groundwater treatment would be initiated. Pump settings and the air circulation rates would be adjusted to obtain a flow rate of 20 gpm within each well.

Operation and Maintenance. Table 6-1 includes the factors affecting the operation and required maintenance for this alternative.

6.1.3 Technical Criteria Assessment This section provides the overall technical criteria assessment for Alternative 1. Combined effects of implementing *ex-situ* and *in-situ* treatments are presented for each of the criteria.

Overall Protection of Human Health and the Environment. This alternative is protective of human health and environment because it would be designed and operated to minimize migration of groundwater and would reduce VOC contaminants in groundwater from OU 1.

Migration stabilization and prevention of contaminant transfer to the surface water is accomplished by extraction of groundwater with treatment via UV/oxidation and discharge of treated effluent to the FOTW.

Reduction of VOC contaminants in groundwater within the OU 1 area is accomplished by *in-situ* air stripping with onsite treatment of off-gas via synthetic resin adsorption.

Compliance with ARARs. This technology would be designed and operated to meet all chemical-and location-specific ARARs for groundwater remediation. Action-specific ARARs for this technology are listed in Chapter 3.0.

Long-term Effectiveness and Permanence. This focused feasibility study does not address all contaminated groundwater at OU1; however, it will prevent further migration of contaminated groundwater from the OU and would reduce VOC contaminants in groundwater. The overall long-term effectiveness and permanence of this alternative, will be evaluated, in the overall FS for OU1.

Because an overall FS is proposed to be in place before this FFS is terminated, the magnitude of residual risk will be evaluated during implementation of overall FS.

Reduction in Toxicity, Mobility, or Volume. During *ex-situ* treatment of groundwater by UV/oxidation, VOC contaminants are permanently destroyed; the technology is irreversible. Groundwater will be treated to meet the pre-treatment standards for FOTW. Destruction of VOCs is expected to be greater than 99 percent.

During *in-situ* treatment of groundwater by air stripping; VOC contaminants are removed from groundwater and are permanently destroyed through off-gas treatment. Destruction of VOCs is expected to be greater than 90 percent **(source.)**.

Short-term Effectiveness. Potential impacts to human health and the environment in the short-term are minimal for this alternative because the contaminated groundwater would either be treated *in-situ* or contained until treatment for *ex-situ* treatment. Also, for *ex-situ* treatment, system shut-off valves and leak detection devices will be in place to prevent potential spills and adverse effects to human health and environment.

Potential risks to human health during the construction and system start-up include: potential exposure to contaminated drill cuttings and VOC vapors.

There would be no O_3 emissions from the UV/oxidation system because residual O_3 would be reduced to oxygen. H_2O_2 can be reduced to harmless gases and water. Therefore, no adverse human health or environmental impacts are expected during implementation. Air monitoring devices and system shutoff controls will be installed to prevent potential adverse effects to the community during implementation. Areas occupied by the treatment systems will be secured by installing physical barriers and display signs.

Implementability.

***Ex-situ* Treatment via UV/oxidation and Onsite Treatment of Off-Gas** As demonstrated through pilot-scale testing and full-scale operations at other CERCLA sites, UV/Oxidation is applicable to treating chlorinated organics in groundwater.

Monitoring will be required to ensure that effluent quality standards are met. Sampling and analysis will be performed to the influent (contaminated groundwater), effluent (treated groundwater), and ambient air. During system star-up, sampling will be conducted every week for 15 weeks, during the 5-years of operation, effluent will be sampled quarterly. However, actual sampling interval would be designed to meet the pretreatment requirements for the FOTW. Appendix E, presents details of pretreatment standards for the FOTW.

Suspended solids and metals interfere with performance reliability. Dissolved metals oxidize in the presence of O_3 and H_2O_2 and precipitate within the reaction vessel. These metal precipitates, as well as other suspended solids, reduce penetration of UV light and diminish the overall ability of the system to oxidize organic compounds. Installing a UV/oxidation system with specially designed wipers for keeping the quartz sleeve clean at all the times would ensure the integrity of the treatment. Also, controlling the pH for high iron content in the influent groundwater (exceeding 10 parts per million) would not only keep the metals from precipitating, but also improve the efficiency of oxidation process.

Implementability of the discharge option chosen for the treated groundwater depends on the existing hydraulic capacity of the FOTW. Since the FOTW is being operated at less than 40 percent of designed flow rates, this alternative is feasible to implement.

***In-situ* Air Stripping** As demonstrated through pilot-scale testing and full-scale operations at other CERCLA sites, *in-situ* air stripping of groundwater using vertical circulation wells is applicable to treating chlorinated organics. Groundwater flow modeling will be required to optimize the location of wells. As proposed in Chapter 2.0, once data from the pump tests is available, the system design parameters will be fine tuned to improve performance of the system.

Suspended solids and metals may interfere with performance reliability of the groundwater treatment system. These metal precipitates, as well as other suspended solids, may decrease the efficiency of groundwater circulation through the well screens, consequently decreasing the contact time between the contaminated water and the *in-situ* air stripping reactor. Therefore, the vertical circulation well screens are designed to facilitate back washing and removal of accumulated particulate matter as part of routine maintenance.

Monitoring will be required to ensure treatment efficiency of *in-situ* air stripping. During system start-up, sampling of off-gas will be conducted once per week for 15 weeks, for the 5-years of operation. Downgradient monitoring wells will be sampled quarterly.

Cost. Table 6-2 provides a cost estimate for this Alternative including:

- a collection and treatment of groundwater via UV/oxidation with discharge to FOTW; and

- an *in-situ* treatment via air stripping and onsite treatment of off-gas.

The capital costs of this alternative are estimated to be $ 1,615,000. Operation, maintenance, and monitoring costs are expected to total $ 366,000 per year for the entire system. These costs are for a 20 gpm *in-situ* treatment system, and 40 gpm *ex-situ* system, only. These costs are sensitive to the type of contaminants present in the waste stream, contaminant concentrations, and target treatment levels. Costs for post-project removal of the recovery systems were not included because it is assumed that the extraction system and the treatment units proposed for this alternative would be utilized later for a complete restoration of the aquifer at OU 1. The impact on the O & M expenses of the FOTW are not included in this evaluation.

6.2 ALTERNATIVE 2, *EX-SITU* TREATMENT VIA UV/OXIDATION; AND *IN-SITU* AIR SPARGING.

This alternative consists of the implementation of technologies to achieve the RAOs, established in Chapter 4.0. RAO 1 would be achieved through collection and *ex-situ* treatment of groundwater via UV/oxidation with offsite discharge of

Table 6-2
Cost Estimates for Alternative 1

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Alternative 1: Collection and Treatment via UV/oxidation; In-Situ Treatment via Air Stripping by Vertical Circulation Well

CAPITAL COSTS			
Direct			
UV/Oxidation	Extraction System (drilling and installation, piping, and pumps for 3 wells)		62,225
	Building, equipment, piping, and controls		
	Building (3,600 square feet @ $50 per square foot)		180,000
	UV/Oxidation 15-25 gallons per minute (gpm)		75,000
	Installation (@ 30 percent of UV/Oxidation)		22,500
	Site Preparation, grading, paving, and fencing		20,000
	Utilities (water, sewer, and electricity)		25,000
	Discharge system (excavation 2-foot by 1-foot trench, PVC piping @ $25/LF)		
	Less than 2,000 feet from the treatment plant to the FOTW/nearest manhole		50,000
Vertical Circulation Well	Drilling (2 wells @ $5,000 each)		10,000
	Building, equipment, piping, and controls		
	Building (3,600 square feet @ $50 per square foot)		180,000
	Vertical circulation well with the air stripping reactor (2 units @ $70,000 each)		140,000
	Synthetic adsorption (closed-loop adsorbent regeneration)		230,000
	Installation (@ 30 percent of the treatment unit, i.e., 0.3 X 180,000)		111,000
	Site preparation, grading, paving, and fencing		20,000
	Utilities (water, sewer, and electricity)		25,000
		Subtotal	1,150,725
Indirect			
	Engineer, construction permit, and administration @ 20 percent		230,145
	Health and safety @ 20 percent		230,145
		Total Capital Costs	1,611,015

ANNUAL OPERATION AND MAINTENANCE (O&M) COSTS			
UV/oxidation	Equipment maintenance and replacement		
	Building	180,000	
	Extraction system...pumps	3,225	
	Equalization tank	1,000	
	Trans. pumps	1,200	
	UV/Oxidation	75,000	
	5 percent of the Subtotal	260,425	13,021
	Electricity, chemicals, and materials		
	Extraction system (3 extractions @ 0.3 horsepower (HP) + 2 trans @ 1 HP) @ $0.08 per kilowatt hour (KWH) and 75 percent efficiency		2,088
	UV/Oxidation @ 30 KWH, & 75 percent efficiency)		28,032
	UV/Oxidation H_2O_2 @ $4.5 per 1,000 gallons (21,600 gallons per day X $4.5 per 1,000 gallon)		35,478
	Manpower (1 X $50,000 per year)		50,000
	System monitoring (quality control of the operating parameters)		10,000
	Site monitoring (performance evaluation including sampling and analysis)		56,250
	5-Year site review 25,000(A/F, 5 percent, 5)		4,500
	UV/Oxidation Subtotal		199,370

See notes at end of table.

Table 6-2 (Continued)
Cost Estimates for Alternative 1

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Alternative 1: Collection and Treatment via UV/oxidation; In-Situ Treatment via Air Stripping by Vertical Circulation Well

Vertical Circulation Well	Equipment maintenance and replacement			
	Building	180,000		
	In-situ air stripping reactor	140,000		
	Synthetic adsorption unit	230,000		
	5 percent of the Subtotal	550,000	27,500	
	Electricity			
	Vertical circulation and air stripping (@ $400 per month)		4,800	
	Adsorption unit, (regeneration, solvent disposal @ 1,000 per month)		12,000	
	Synthetic adsorption unit			
	Blower (@ 1 HP) @ 75 percent efficiency		696	
	Manpower (1 X $50,000 per year)		50,000	
	System monitoring (quality control of the operating parameters)		10,000	
	Site monitoring (performance evaluation including sampling and analysis)		56,250	
	5-Year site review, 25,000 (A/F, 5 percent, 5)		4,500	
	Vertical Circulation Well Subtotal		165,746	
	Total O&M costs			365,116
	Present-worth O&M @ (5 percent, 5, OM) * 4.32			1,577,300
Total Capital Costs and 5-Year O&M Costs Present Worth				**3,188,315**

Notes: UV = ultraviolet.
PVC = polyvinyl chloride.
LF = linear feet.
FOTW = facility owned treatment works.
H_2O_2 = hydrogen peroxide.
A/F = annual/future.

effluent to FOTW; and RAO 2 would be achieved through treatment of groundwater via *in-situ* air sparging with soil vapor extraction.

The following subsections provide a description of the principles upon which each of the technologies are based, methods for managing waste streams produced through treatment, factors affecting the cost and performance of each of the technologies, and the operational logistics for implementing the alternative.

A site layout for this alternative is presented in Figure 6-7.

<u>6.2.1 Collection and *Ex-situ* Treatment via UV/oxidation, with Offsite Discharge to FOTW</u> This section is same as for Alternative 1.

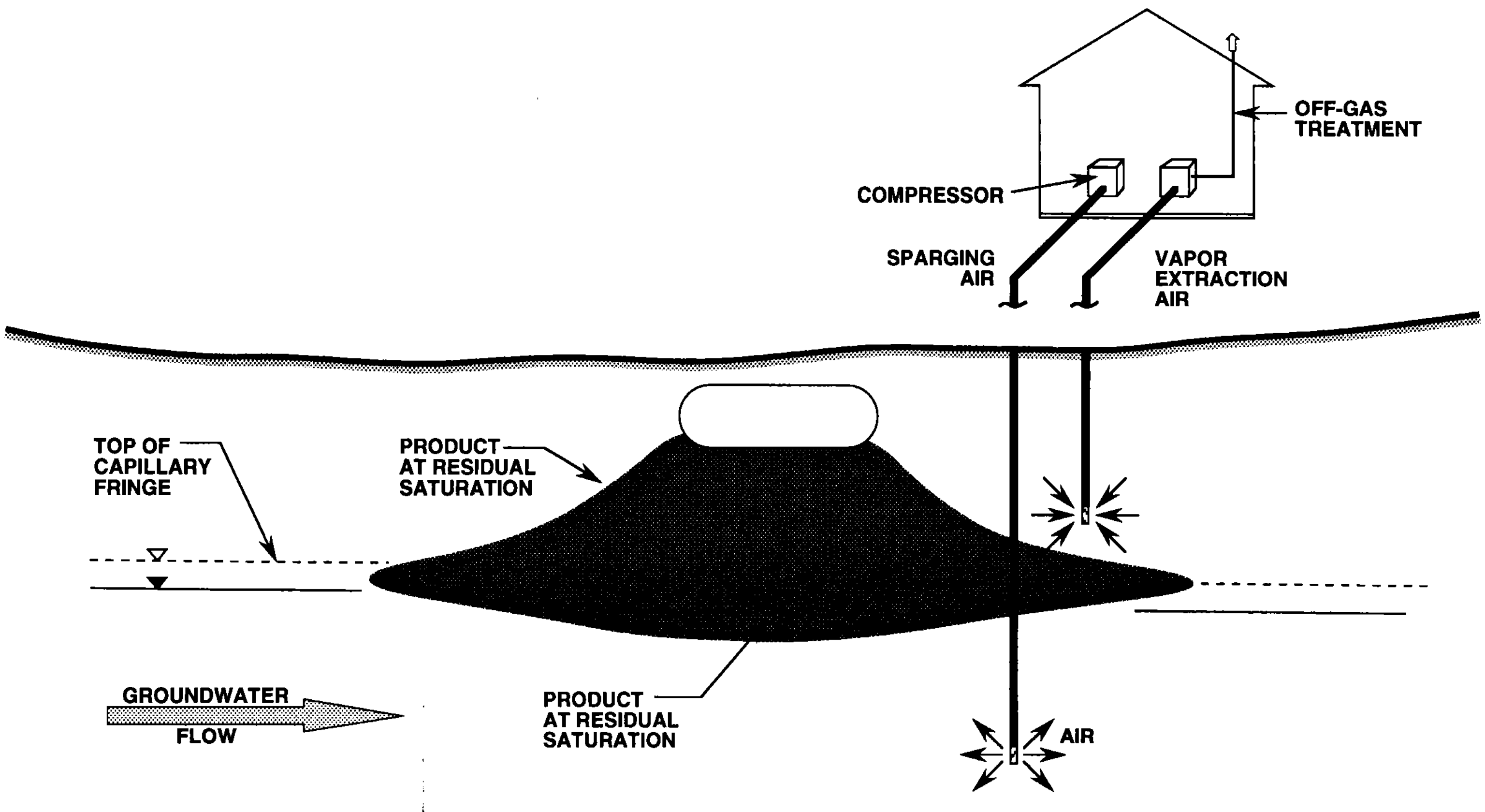
<u>6.2.2 *In-situ* Treatment via Air Sparging</u>

<u>Description</u>. *In-situ* air sparging is the injection of air directly into a saturated soil matrix. As injected air bubbles rise through the saturated zone, dissolved volatile contaminants are transferred from the aqueous phase to the vapor phase by diffusion (Figure 6-8). Volatile contaminants diffused into the vadose zone and are captured by a Soil Vapor Extraction (SVE) system. SVE is the creation of negative pressure gradients in a series of zones within unsaturated soil, while inducing subsurface airflow. The vapor extraction system is connected to transfer pipes which are then manifolded to a vacuum unit for collection and treatment of contaminated air.

The major activities associated with this technology include the following:

- site clearing and preparation,
- installation of air sparging system,
- installation of Extraction system,
- installation of off-gas treatment unit,
- start-up of the *in-situ* air sparging and soil vapor extraction system, and
- operation and maintenance of the treatment system.

Figure 6-7 Site Lay-Out for Alternative 2



SOURCE: *GROUND WATER MONITORING & REMEDIATION*, FALL 1993

FIGURE 6-8 SCHEMATIC OF AN IN-SITU AIR SPARGING / SOIL VAPOR EXTRACTION SYSTEM	FOCUSED RI/FS CONTAMINANT PLUME REDUCTION AT OU 1 NAS JACKSONVILLE, JACKSONVILLE, FLORIDA

7565-16 940715WEM

A process flow diagram for this alternative is provided in Figure 6-9.

Site Clearing and Preparation. Site clearing and preparation would include all activities or construction necessary prior to installation of a groundwater treatment system at the OU. These activities would include:

- construction of bermed concrete pads for staging of the air sparging and vapor extraction system and off-gas treatment unit; and

- installation of a compound around the equipment with clearing and grubbing of trees that may interfere with the installation of the treatment system, piping, or any other units.

Clearing and grubbing of ground cover, stumps, and trees at the OU would be minimal, but may be necessary prior to construction for this technology. Construction permits, work permits, and site clearance would be obtained prior to beginning intrusive work at OU 1. All underground utilities would be located and staked.

Installation of the Air Sparging with SVE System. This subsection describes preliminary design of the Air Sparging technology.

Information required for an effective Air Sparging/SVE design consist of the following:

- location of potential vapor receptors,
- geological conditions of the site,
- contaminant mass distribution,
- radius of influence for both soil vapor extraction and air sparging,
- design air flow, vacuum and pressure, and
- equipment specifications.

Site assessment data previously discussed in Chapter 2.0 provided information concerning subsurface geologic conditions and contaminant mass distribution. The information required for the determination of vent and sparge radii of influence, design flow rate, and equipment specifications is obtained by using a mathematical

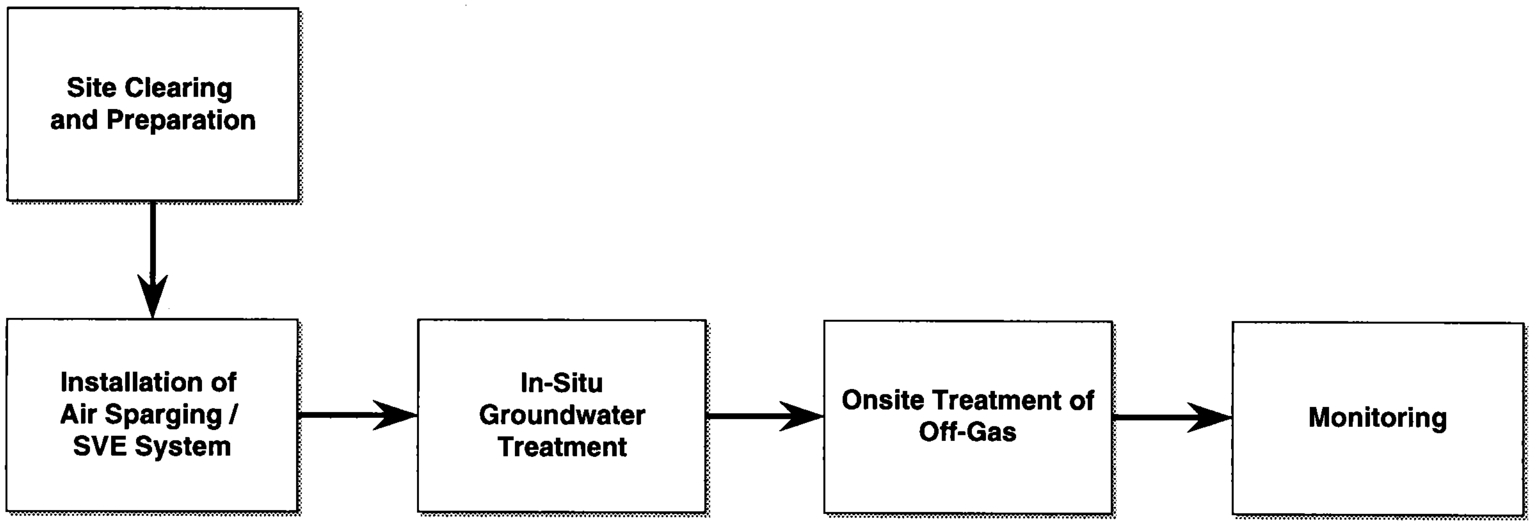


FIGURE 6-9

FLOW PROCESS DIAGRAM FOR ALTERNATIVE 2, IN-SITU TREATMENT VIA AIR SPARGING

FOCUSED RI/FS
CONTAMINANT PLUME REDUCTION AT OU 1

NAS JACKSONVILLE, JACKSONVILLE, FLORIDA

7565-16 940715WEM

model (Appendix A). In the absence of a pilot scale study results, certain assumptions as included in Appendix A were made to obtain the design parameters for the air sparging/SVE system. Detail of the preliminary design are as follows.

- A line of sparging wells will be installed approximately perpendicular to the general direction of the groundwater flow at the boundary of the OU (see Figure 6-7).

- A vapor collection trench parallel to and downgradient from the air sparging wells and upgradient from local residences for extraction os soil vapor.

- Compressors to supply air to the sparging wells and blowers to remove vapors from the vapor collection trench.

The compressor supplies air to 15 air sparging wells at an average flow rate of 25 cubic feet per minute (cfm) and at a pressure of 25 pounds per square inch (psi). The wells would be spaced approximately 60 feet apart and screened from 32 to 37 feet below the water table. A vapor extraction blower would withdraws vapor at a rate of 1,500 cfm at a vacuum of 75 inches from a 1,200-foot-long, 4-inch diameter vacuum line installed 6 feet below grade.

The existing monitoring well network installed at the OU is proposed to be used for monitoring the saturated groundwater zone. An additional 20 piezometers would be proposed to be installed to monitor vapor in the vadose zone.

As mentioned earlier, an air sparging/SVE pilot study was not conducted prior to this FFS. Therefore, it will be necessary to conduct start-up testing of the air sparging and SVE system to fine tune and adjust the system parameters.

<u>Installation of Off-Gas Treatment Unit</u>. Installation of an off-gas treatment unit for extracted vapors would be similar to the treatment methods discussed for Alternative 1.

<u>Start-up of *In-situ* Groundwater Treatment System</u>. Once the air sparging and SVE system with the associated appurtenances are installed, groundwater treatment would be initiated.

Operation and Maintenance. Table 6-3 presents the factors affecting the operation and required maintenance for this alternative at OU1.

6.2.3 Technical Criteria Assessment This section provides overall technical criteria assessment for Alternative 2. Combined effects of implementing *ex-situ* and *in-situ* treatments are presented for each of the criteria.

Overall Protection of Human Health and the Environment. This technology is protective of human health and environment because it would be designed and operated to minimize migration of groundwater and to reduce VOC contaminants in groundwater from OU 1 area.

Migration stabilization and prevention of contaminant transfer to the surface water is accomplished by extraction of groundwater with treatment via UV/oxidation and discharge of treated effluent to the FOTW.

Reduction of VOC contaminants in groundwater within the OU 1 area is accomplished by *in-situ* air stripping with onsite treatment of off-gas via synthetic resin adsorption.

Compliance with ARARs. This technology would be designed and operated to meet all chemical-and location-specific ARARs for groundwater remediation. Action-specific ARARs for this technology are listed in Chapter 3.0.

Long-term Effectiveness and Permanence. This focused feasibility study does not address all contaminated groundwater at OU1; however, it will prevent further migration of contaminated groundwater from the OU and would reduce VOC contaminants in groundwater. The overall long-term effectiveness and permanence of this alternative, will be evaluated, in the overall FS for OU1.

Table 6-3
Factors Affecting Operation and Maintenance for Alternative 2

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

ALTERNATIVE 2. Collection and Treatment via UV/oxidation, Discharge to FOTW; In-situ Treatment via Air Sparging and SVE.

	Operation	Maintenance
Extraction System	Extraction pump flow rates	Extraction pump and associated units
UV/Oxidation	Influent flow control	Flow equalization tank and associated manifold
	Influent Water Quality Monitoring	
	Influent water pH, turbidity control	
	UV light energy monitoring and control	Cleaning of lamps and sleeve
	H_2O_2 dosage control	H_2O_2 containers and associated safety valves
	Air quality monitoring	Air quality monitoring equipment
FOTW Discharge	Discharge rates	Piping and lift pumps
	Effluent water quality monitoring and control	
In-situ Air Sparging and SVE	Air sparging and SVE air flow rates, and pressure control	Compressors, blowers, well screens and associated appurtenances
	Off-gas collection, and flow monitoring	
	Influent off-gas quality monitoring	
	Effluent off-gas quality control	Temperature, humidity, of vapor phase adsorption beds
	Air quality monitoring	Air quality monitoring equipment

Notes: UV = ultraviolet.
H_2O_2 = hydrogen peroxide.
FOTW = facility owned treatment works.

Because an overall FS is proposed to be in place before this FFS is terminated, the magnitude of residual risk will be evaluated during implementation of overall FS.

Reduction in Toxicity, Mobility, or Volume. During *ex-situ* treatment of groundwater by UV/oxidation, VOC contaminants are permanently destroyed; the technology is irreversible. Groundwater will be treated to meet the pre-treatment standards for FOTW. Destruction of VOCs is expected to be greater than 99 percent.

During the *in-situ* treatment by air sparging and soil vapor extraction, VOC contaminants are removed from groundwater and are permanently destroyed through off-gas treatment. Destruction of VOCs is expected to be greater than 90 percent.

Short-term Effectiveness. Potential impacts to human health and the environment are minimal for this alternative because the groundwater would either be treated *in-situ* or contained for *ex-situ* treatment. Also, for *ex-situ* treatment, system shut-off valves and leak detection devices will be in place to prevent potential spills and adverse effects to human health and environment.

Potential risks to human health during construction and system start-up for this alternative include: potential exposure to contaminated drill cuttings and VOC vapors. There would be no O_3 emissions from the UV/oxidation system because residual O_3 would be reduced to oxygen. H_2O_2 can be reduced to harmless gases and water. Therefore, no adverse human health or environmental impacts are expected during implementation. Air monitoring devices, and system shutoff controls will be installed to prevent potential adverse effects to the community during implementation. Areas occupied by the treatment systems will be secured by installing physical barriers and signs.

The physics of air movement in saturated porous media are not widely understood. Air movement within the saturated zone is extremely sensitive to formation structure. Additionally, if the sparging system were to be installed closer to residential areas, there is a potential for uncontrolled air movements near the areas where underground utilities are present.

Implementability.

***Ex-situ* Treatment via UV/oxidation and Onsite Treatment of Off-Gas** This discussion is similar to the discussion for Alternative 1.

***In-situ* Air Sparging and SVE** As demonstrated through pilot-scale testing and full-scale operations at other CERCLA sites, *in-situ* air sparging and SVE for groundwater is applicable to treating chlorinated organics. Pilot scale studies would need to be performed to optimize the location of air sparging and vapor extraction wells.

Monitoring would be required to ensure the treatment efficiency of the *in-situ* air sparging and SVE system. During system start-up, sampling would be conducted once per week for 15 weeks for the 5-years of operation. Downgradient monitoring wells will be sampled quarterly. Vadose zone and saturated zone monitoring points would be installed in the following locations: (1) directly downgradient from the sparging well system, (2) directly downgradient from the vent trench, and (3) generally within down gradient of the zone targeted for remediation.

Cost. This section provides a cost estimate for Alternative 2 including:

- collection and treatment of groundwater via UV/oxidation with discharge to FOTW; and
- *in-situ* treatment via air sparging in conjunction with SVE with onsite treatment of off-gas.

Table 6-4 presents summary of cost estimates for implementing Alternative 2.

The capital costs for Alternative 2 are estimated to be $ 1,873,000. Operation, maintenance, and monitoring costs are expected to total $ 407,400 per year. These costs are for a 20 gpm *in-situ* treatment system, and 40 gpm *ex-situ* system, only. These costs are sensitive to the type of contaminants present in the waste stream, contaminant concentrations, and target treatment levels. Costs for post-project removal of the recovery systems were not included because it is assumed that the extraction system and the treatment units proposed for this alternative would be utilized later for a complete restoration of the aquifer at OU 1. The impact on the O & M expenses of the FOTW are not included in this evaluation.

6.3 ALTERNATIVE 3, COLLECTION AND *EX-SITU* TREATMENT VIA AIR-STRIPPING, CARBON ADSORPTION, DISCHARGE TO FOTW, AND *IN-SITU* AIR STRIPPING VIA VERTICAL CIRCULATION WELL. This alternative consists of the implementation of technologies to achieve the RAOs, established in Chapter 4.0. RAO 1 would be achieved through collection and *ex-situ* treatment of groundwater via air stripping and Carbon Adsorption with offsite discharge of effluent to FOTW; and RAO 2 would be achieved through *in-situ* air stripping via vertical circulation well.

The following subsections provide a description of the principles upon which each of the technologies are based, methods for managing waste streams produced through treatment, factors affecting the cost and performance of each of the technologies, and the operational logistics for implementing the alternative.

A site layout for this alternative is included in Figure 6-1.

6.3.1 Collection and *Ex-situ* Treatment via Air Stripping and Carbon Adsorption with Offsite Discharge to FOTW

Description. This alternative would consist of the installation of a network of extraction wells to extract groundwater and stabilize the migration. Extracted groundwater would be pumped to an equalization tank located on site for subsequent feed into the treatment unit. Effluent from the treatment unit would be followed by the discharge to the FOTW.

The major activities associated with this alternative include the following:

- site clearing and preparation,
- installation of extraction system,
- installation of UV/oxidation system,
- installation of an Air-Stripping System and Carbon Adsorption System,
- installation of off-gas treatment system,
- installation of piping to the FOTW,

Table 6-4
Cost Estimates for Alternative 2

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Alternative 2: Collection and Treatment via UV/Oxidation; In-Situ Treatment via Air Sparging/Soil Vapor Extraction (SVE)

CAPITAL COSTS				
Direct				
UV/Oxidation	Extraction System (drilling and installation, piping, and pumps for 3 wells)			62,225
	Building, equipment, piping, and controls			
	Building (3,600 square feet @ $50 per square foot)			180,000
	UV/Oxidation 15 to 25 gallons per minute (gpm)			75,000
	Installation (@ 30 percent of UV/Oxidation)			22,500
	Site preparation, grading, paving, and fencing			20,000
	Utilities (water, sewer, and electricity)			25,000
	Discharge system (excavation 2-foot by 1-foot trench, PVC piping @ $25/LF)			
	Less than 2,000 feet from the treatment plant to the FOTW/nearest manhole			50,000
Air Sparging/ SVE	Drilling for air sparging and SVE (25 wells @ $5,000)			125,000
	Building, equipment, piping, and controls			
	Air sparging system (15 air spargers @ $ 5,000 each)			75,000
	Soil vapor extraction system (10 SVE wells @ $ 5,000 each)			50,000
	Building (3,600 square feet @ $50 per square foot)			180,000
	Synthetic adsorption unit (closed loop adsorbent regeneration)			230,000
	Installation (@ 30 percent of air sparging system, SVE system, and off-gas treatment)			198,000
	Site preparation, grading, paving, and fencing			20,000
	Utilities (water, sewer, and electricity)			25,000
	Subtotal			1,337,725
Indirect				
	Engineer, construction permit, and administration @ 20 percent			267,545
	Health and safety @ 20 percent			267,545
	Total Capital Costs			1,872,815
ANNUAL OPERATION AND MAINTENANCE COSTS				
UV/Oxidation	Equipment maintenance and replacement			
	Building	180,000		
	Extraction system...pumps	3,225		
	Equalization tank	1,000		
	Trans. pumps	1,200		
	UV/Oxidation	75,000		
	5 percent of the Subtotal	260,425	13,021	
	Electricity, chemicals, and materials			
	Extraction system (3 extractions @ 0.3 horsepower (HP) + 2 trans @ 1 HP) @ $0.08 per kilowatt hour (KWH) and 75 percent efficiency		2,088	
	UV/Oxidation @ 30 KWH and 75 percent efficiency)		28,032	
	UV/Oxidation H_2O_2 @ $4.5 per 1,000 gallons, 21,600 gallons per day X $4.5 per 1,000 gallons		35,478	
	Manpower (1 X $50,000 per year)		50,000	
	System monitoring (quality control of the operating parameters)		10,000	
	Site monitoring (performance evaluation including sampling and analysis)		56,250	
	5-Year site review 25,000 (A/F, 5 percent, 5)		4,500	
	UV/Oxidation Subtotal		199,370	

See notes at end of table.

Table 6-4 (Continued)
Cost Estimates for Alternative 2

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Alternative 2: Collection and Treatment via UV/Oxidation; In-Situ Treatment via Air Sparging/Soil Vapor Extraction (SVE)

AS/SVE				
	Equipment maintenance and replacement			
	Building	180,000		
	Air sparging system	125,000		
	SVE system	75,000		
	Synthetic adsorption unit	230,000		
	5 percent of the Subtotal	610,000	30,500	
	Electricity, chemicals, and materials			
	Air sparging system ($1,000 per month)		12,000	
	SVE system ($1,000 per month)		12,000	
	Synthetic adsorption including regeneration			
	Blower (@ 1 HP) @ 75 percent efficiency		696	
	Electricity, regeneration, and solvent disposal @ 1000 per month		12,000	
	Manpower (1 X $50,000 per year)		50,000	
	System monitoring (quality control of the operating parameters)		30,000	
	Site monitoring (performance evaluation including sampling and analysis)		56,250	
	5-Year site review, 25,000 (P/F, 5 percent, 5)		4,500	
	AS/SVE Subtotal		207,946	
	Total O&M costs			407,316
	Present-worth O&M @ (5 percent, 5, OM) * 4.32			1,759,604
Total Capital Costs and 5-Year O&M Costs Present Worth				**3,632,419**

Notes: UV = ultraviolet.
PVC = polyvinyl chloride.
LF = linear feet.
FOTW = facility owned treatment works.
H_2O_2 = hydrogen peroxide.
A/F = annual/future.
P/F = present/future.

- start-up of the extraction system and treatment unit, and
- operation and maintenance.

A process flow diagram for this alternative is provided in Figure 6-10.

Site Clearing and Preparation. Site clearing and preparation, would be the same as described for Alternative 1.

Installation of Extraction System. Installation of extraction system, would be the same as described for Alternative 1.

Primary Treatment through Air-Stripping. Air stripping is frequently used to remove VOCs and SVOCs including those found at OU 1, from wastewater and groundwater by contacting contaminated water with large volumes of air. Contaminants are transferred from the liquid phase to the gaseous phase. Figure 6-11 is a schematic of air-stripping system. Inorganic compounds in waste stream may be oxidized during the air-stripping process. Iron, manganese, calcium, and magnesium, commonly found in groundwater, may be present in the waste stream in a reduced oxidation state. Contact with air can cause these inorganics to oxidize to a less soluble form and subsequently precipitate out of the water. This can cause scaling and fouling of the packing material or produce a metal hydroxide sludge requiring treatment and disposal. Pretreatment of the influent may also be required for waste streams containing large amounts of suspended solids, oils and greases, or other inorganic contaminants that can foul the air-stripper. The Air-stripping technology is a well-proven and widely used technology for many VOCs and SVOCs produces a consistent-quality effluent in a properly designed and maintained unit. Removal efficiencies of greater than 98 percent for VOCs and greater than or equal to 80 percent for SVOCs have been achieved at other sites.

If effluent form the air stripper does not meet the treatment standards, activated carbon adsorption, would effectively remove organic materials from water by sorption (or the attraction and accumulation of one substance on the surface of another). As water passes through porous granules of carbon, contaminant molecules are attracted to the surface of the pores and held there by week physical forces.

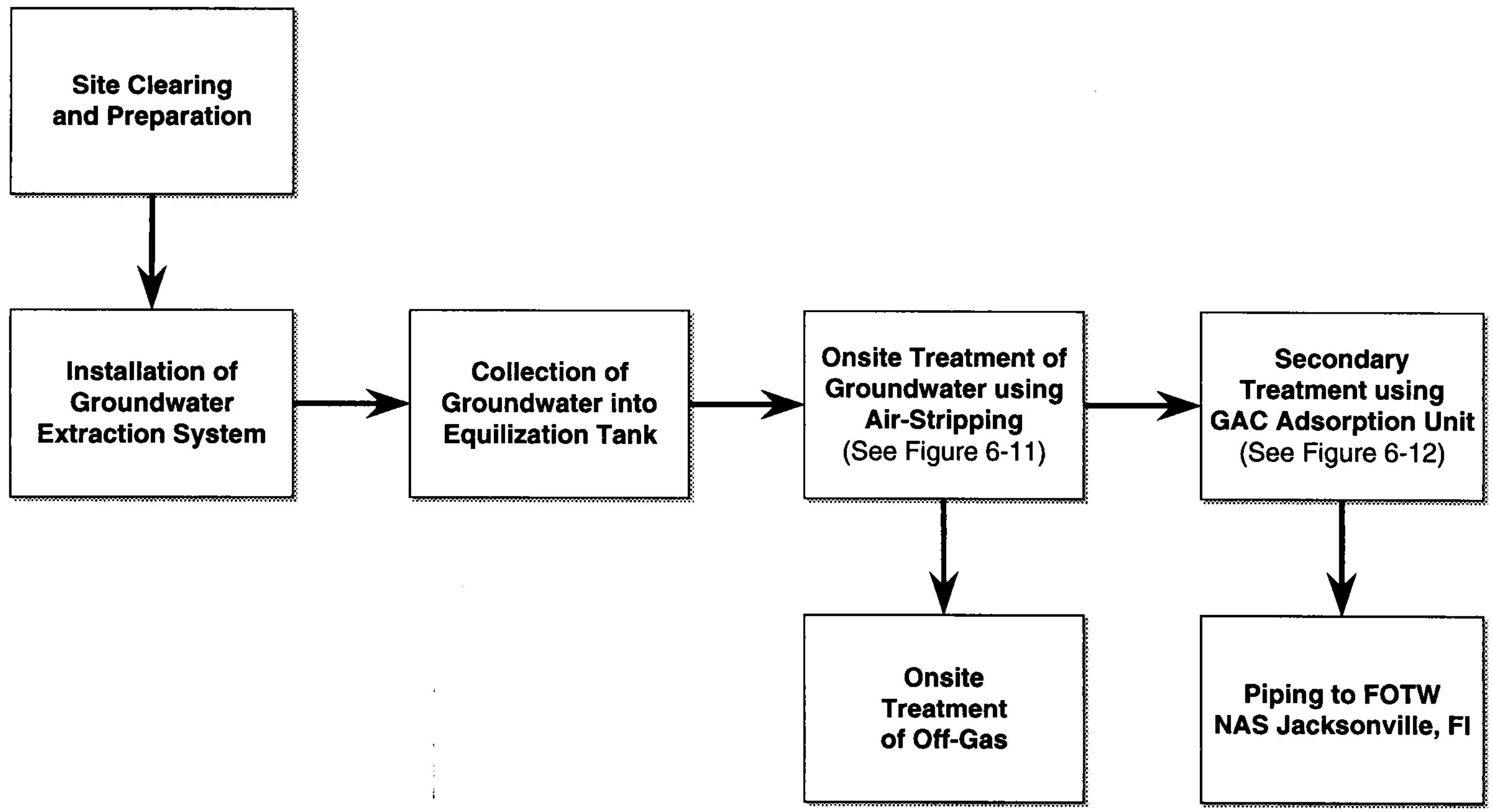


FIGURE 6-10

FLOW PROCESS DIAGRAM FOR ALTERNATIVE 3, EX-SITU TREATMENT VIA AIR STRIPPING AND GAC ADSORPTION

FOCUSED RI/FS
CONTAMINANT PLUME
REDUCTION AT OU 1

NAS JACKSONVILLE,
JACKSONVILLE, FLORIDA

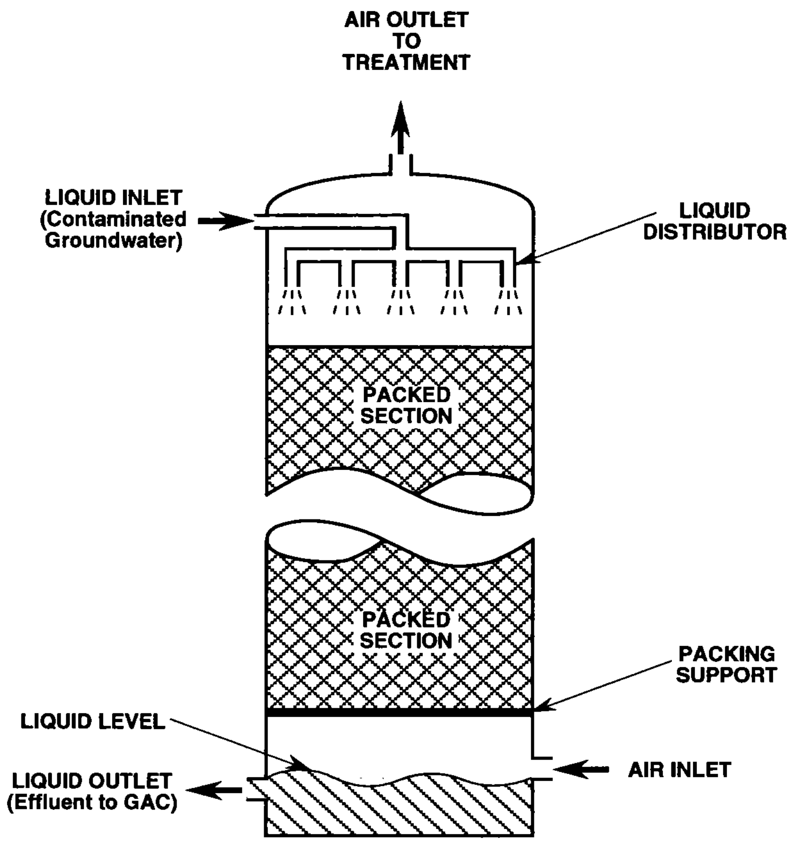


FIGURE 6-11

SCHEMATIC OF AIR STRIPPER

FOCUSED RI/FS
CONTAMINANT PLUME
REDUCTION AT OU 1

NAS JACKSONVILLE,
JACKSONVILLE, FLORIDA

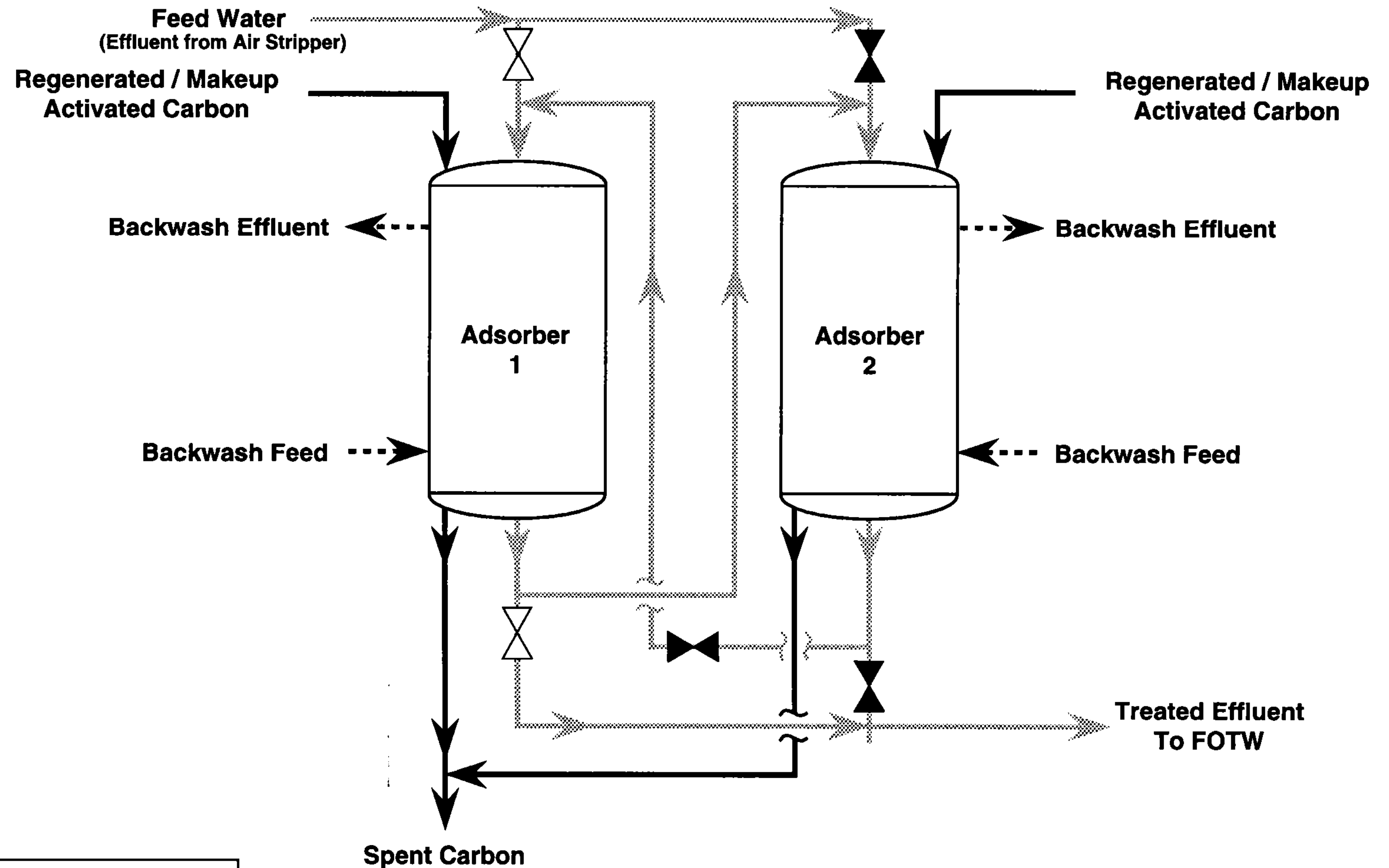
7565-16 940715WEM

Secondary Treatment through Granular Activated Carbon (GAC) Adsorption. If effluent form the air stripper does not meet the treatment standards, activated carbon adsorption, would effectively remove organic materials from water by sorption (or the attraction and accumulation of one substance on the surface of another). As water passes through porous granules of carbon, contaminant molecules are attracted to the surface of the pores and held there by week physical forces. Adsorption is a widely-used process for the removal of organic contaminants from gas or liquid waste streams. Activated carbon is the most commonly used adsorbent. Largely non-polar, carbon is particularly effective for the removal of hydrophobic, high molecular weight organic compounds from aqueous streams. Thus, it is a good adsorbent for many of the halogenated organic compounds. Activated carbon adsorption is used either as a primary treatment for moderately high (up to 0.5 percent by weight) concentrations of organic compounds or as a secondary polishing type treatment for much lower levels of contamination.

As activated carbon adsorbs molecules from water, the carbon pores become saturated with the toxic contaminants. An activated carbon adsorption system would require units to be connected in series and a standby unit to be used during a replacement of spent carbon or if break through occurs. Figure 6-12 illustrates a schematic of a typical carbon adsorption system. Regular sampling of effluent from the first carbon bed in the series would be required to assess the breakthrough point. Breakthrough occurs when the concentration of the target pollutant in the effluent is higher than the desired level. Once the carbon has been spent, a new charge of carbon would be brought in to replace the spent carbon. Spent carbon would be reactivated offsite to be used again onsite at a later date. Minimal carbon waste is generated. Pretreatment of the influent may be required if the wastewater stream contains large amounts of suspended solids, metal, oils, and greases, or other inorganic contaminants that may foul the carbon beds.

Installation of Off-Gas Treatment System. Off-gas treatment for this alternative is similar to the technologies described for Alternative 1.

Start-up of Extraction System. Start-up of extraction system is similar to the technologies described for Alternative 1.



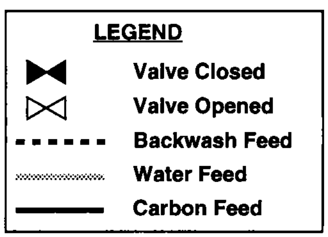


FIGURE 6-12

SCHEMATIC OF GRANULAR ACTIVATED CARBON ADSORPTION

FOCUSED RI/FS
CONTAMINANT PLUME
REDUCTION AT OU 1

NAS JACKSONVILLE,
JACKSONVILLE, FLORIDA

7565-16 940608WEM

Operation and Maintenance. Table 6-5 presents the factors affecting the operation and required maintenance for Alternative 3 at OU1.

6.3.2 *In-situ* Treatment via Air Stripping with Vertical Circulation Well The implementation of this technology for Alternative 3 is as described for Alternative 1.

6.3.3 Technical Criteria Assessment This section provides overall technical criteria assessment for Alternative 3. Combined effects of implementing *ex-situ* and *in-situ* treatments are presented for each of the criteria.

Overall Protection of Human Health and the Environment. This alternative is protective of human health and environment because it would be designed and operated to minimize migration of groundwater and would reduce VOC contaminants in groundwater from OU 1.

Migration stabilization and prevention of contaminant transfer to the surface water is accomplished by extraction of groundwater with treatment via Air Stripping and Carbon Adsorption and discharge of treated effluent to the FOTW.

Reduction of VOC contaminants in groundwater within the OU 1 area is accomplished by *in-situ* air stripping with onsite treatment of off-gas via synthetic resin adsorption.

This technology is protective of human health and environment because it would be designed and operated to minimize migration of groundwater and to prevent possible discharge of contamination to surface water and reduce VOC contaminants in groundwater from OU 1 area.

Compliance with ARARs. This technology would be designed and operated to meet all chemical-and location-specific ARARs for groundwater remediation. Action-specific ARARs for this technology are listed in Chapter 3.0.

Table 6-5
Factors Affecting Operation and Maintenance for Alternative 3

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

ALTERNATIVE 3. Collection and Treatment via Air Stripping and Carbon Adsorption, Discharge to FOTW; In-Situ Treatment Via Air Stripping by Vertical Circulation Well.

	Operation	Maintenance
Extraction System	Extraction pump flow rates	Extraction pump and associated units
Air Stripping	Influent water flow control	Flow equalization tank and associated manifold
	Influent water quality monitoring	
	Influent water pH, turbidity control	
	Air flow and pressure monitoring	Cleaning of lamps and sleeve
	Off-gas collection, and flow monitoring	
	Influent off-gas quality monitoring	
	Effluent off-gas quality control	Temperature, humidity, of vapor phase adsorption beds
	Air quality monitoring	Air quality monitoring equipment
GAC Adsorption	Influent water flow control	Lift pump and associated appurtenances
	Effluent water quality control	Regeneration of GAC beds
FOTW Discharge	Discharge rates	Piping and lift pumps
	Effluent water quality monitoring and control	
In-situ Air Stripping via Vertical Circulation Well	Same as Alternative 1.	Same as Alternative 1.

Notes: UV = ultraviolet.
GAC = granular activated carbon.
FOTW = facility owned treatment works.

Long-term Effectiveness and Permanence. This focused feasibility study does not address all contaminated groundwater at OU1; however, it will prevent further migration of contaminated groundwater and reduce the mass of VOC contaminants in groundwater. The overall long-term effectiveness and permanence of this alternative, will be evaluated, in the overall FS for OU1.

Because an overall FS is proposed to be in place before this FFS is terminated, the magnitude of residual risk will be evaluated during implementation of the overall FS.

Reduction in Toxicity, Mobility, or Volume. During the *ex-situ* or *in-situ* treatment by air stripping, VOC contaminants are transferred from groundwater (liquid phase) to the gaseous phase for treatment via absorption. Regeneration of absorption media results in product recovery. Recovered product may be reused. Removal efficiencies for air-stripping of VOCs is expected to be greater than 90 percent. Only VOC contaminants are proposed to be treated in this FFS.

Short-term Effectiveness. Potential impacts to human health and the environment are minimal for this alternative because the groundwater would either be treated *in-situ* or contained for *ex-situ* treatment. Also, for *ex-situ* treatment, system shut-off valves and leak detection devices will be in place to prevent potential spills and adverse effects to human health and environment.

Potential risks to human health during construction and system start-up for Alternative 3 include: the potential exposure to contaminated drill cuttings and VOC vapors. Air monitoring devices, and system shutoff controls will be installed to prevent potential adverse effects to the community during implementation. Areas occupied by the treatment systems will be secured by installing physical barriers and signs.

This FFS will be in place until an overall FS is implemented.

Implementability.

***Ex-situ* Treatment via Air-Stripping, GAC Polish, and Onsite Treatment of Off-Gas.** Approximately two months would be required to construct or assemble structures necessary for Alternative 3. Stripping towers currently process VOCs and SVOCs at hazardous waste sites, manufacturing facilities, and municipal water treatment plants. Onsite facilities have proved successful for a broad range of contaminants and flow rates. Because of the nature of the air-stripping process, a consistent-quality effluent can be obtained, provided there are no large fluctuations in influent concentrations or flow rates. GAC is well-established technology, applicable to various toxic organics and inorganics, which can process flow rates as high as 1 million gallons per day. GAC beds are readily available from manufacturers and can be installed quickly. Full-scale design requires frequent monitoring to determine breakthrough. Off-gas treatment via synthetic adsorption is a proven technology for permanent destruction of organic contaminants in the off-gas from the air strippers. Vendors are available to provide the treatment unit, with minimum maintenance requirements.

Implementability of the discharge option chosen for treated groundwater depends on the existing capacity of the FOTW. Because the FOTW is currently being operated at less than 40 percent of the design flow rate, this alternative is feasible to implement.

***In-situ* Air Stripping**. Implementability for this technology would be as described for Alternative 2.

<u>Cost</u>. Table 6-6 provides a cost estimate for this Alternative that includes costs for:

- *ex-situ* groundwater treatment via air-stripping, Carbon Adsorption with offsite discharge to FOTW and onsite treatment of off-gas, and
- *in-situ* treatment via air stripping with onsite treatment of off-gas.

The capital costs for this alternative are estimated to be $1,986,000. Operation, maintenance, and monitoring costs are expected to total $378,600 per year for the entire system. These costs are for a 20 gpm *in-situ* treatment system and a 40 gpm *ex-situ* system, only. These costs are sensitive to the type of contaminants, contaminant concentrations, and target treatment levels. Costs for post-project removal of the recovery systems were not included because it is assumed that the extraction system and the treatment units would be utilized later for a complete restoration of the aquifer at OU 1.

6.4 ALTERNATIVE 4, COLLECTION AND *EX-SITU* TREATMENT BY AIR-STRIPPING, CARBON ADSORPTION, WITH DISCHARGE TO FOTW; *IN-SITU* TREATMENT VIA AIR SPARGING WITH SVE. This alternative consists of the implementation of technologies to achieve the RAOs, established in Chapter 4.0. RAO 1 would be achieved through collection and *ex-situ* treatment of groundwater via air stripping and carbon adsorption with offsite discharge of effluent to FOTW; and RAO 2 would be achieved through *in-situ* treatment of groundwater via air sparging and vapor extraction.

The following subsections provide a description of the principles upon which each of the technologies are based, methods for managing waste streams produced through treatment, factors affecting the cost and performance of each of the technologies, and the operational logistics for implementing the alternative.

A site layout for this alternative is presented in Figure 6-2.

6.4.1 Collection and *Ex-situ* Treatment via Air Stripping, Carbon Adsorption with Offsite Discharge to FOTW The implementation of this technology was described in Alternative 3.

6.4.2 *In-situ* Air Sparging with SVE The implementation of this technology was described in alternative 2.

6.4.3 Technical Criteria Assessment This section provides the overall technical criteria assessment for Alternative 1. Combined effects of implementing *ex-situ* and *in-situ* treatments are presented for each of the criteria.

Overall Protection of Human Health and the Environment. This alternative is protective of human health and environment because it would be designed and operated to minimize migration of groundwater and would reduce VOC contaminants in groundwater from OU 1.

Table 6-6
Cost Estimates for Alternative 3

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Alternative 3: Collection and Treatment via Air Stripping and Carbon Adsorption; In-Situ Treatment via Air Stripping by Vertical Circulation Well

CAPITAL COSTS			
Direct			
Air Sparging/ GAC	Extraction system		62,225
	Building, equipment, piping, and controls		
	Building (3,600 square feet @ $50 per square foot)		180,000
	Shallow-tray air stripper		15,000
	GAC polisher (two-vessel parallel GAC unit)		15,000
	Synthetic adsorption unit (closed loop adsorbent regeneration)		230,000
	Installation (@ 30 percent of air stripper, GAC polisher, synthetic absorption unit)		105,000
	Site preparation, grading, paving, and fencing		20,000
	Utilities (water, sewer, and electricity)		25,000
	Discharge system (excavation 2-foot by 1-foot trench, PVC piping @ $25/LF)		
	Less than 2,000 feet from the treatment plant to the FOTW/nearest manhole		50,000
Vertical Circulation Well	Drilling (2 wells @ $5,000 each)		10,000
	Building, equipment, piping, and controls		
	Building (3,600 square feet @ $50 per square feet)		180,000
	Vertical circulation well with the air stripping reactor (2 units @ $70,000 each)		140,000
	Synthetic adsorption (closed-loop adsorbent regeneration)		230,000
	Installation (@ 30 percent of the treatment unit, i.e., 0.3 X 180,000)		111,000
	Site preparation, grading, paving, and fencing		20,000
	Utilities (water, sewer, and electricity)		25,000
	Subtotal		1,418,225
Indirect			
	Engineer, construction permit, and administration @ 20 percent		283,645
	Health and safety @ 20 percent		283,645
	Total Capital Costs		1,985,515
ANNUAL OPERATION AND MAINTENANCE (O&M) COSTS			
AS/GAC	Equipment maintenance and replacement		
	Building	180,000	
	Extraction system...pumps	3,225	
	Equipment tank	1,000	
	Trans. pumps	1,200	
	Shallow-tray air stripper	15,000	
	GAC polisher	15,000	
	Synthetic adsorption unit	230,000	
	5 percent of the Subtotal	445,425	22,271

See notes at end of table.

Table 6-6 (Continued)
Cost Estimates for Alternative 3

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Alternative 3: Collection and Treatment via Air Stripping and Carbon Adsorption; In-Situ Treatment via Air Stripping by Vertical Circulation Well

	Electricity, chemicals, and materials		
	Extraction system (3 extractions @ 0.3 horsepower (HP) + 2 trans @ 1 HP) @ $0.08 per kilowatt hours (KWH) and 75 percent efficiency		2,088
	Shallow-tray air stripper		3,000
	GAC unit (including carbon regeneration)		33,000
	Synthetic adsorption including regeneration		
	Blower (@ 1 HP) @ 75 percent efficiency		696
	Electricity, regeneration, and solvent disposal @ 1,000 per month		12,000
	Manpower (1 X $50,000 per year)		50,000
	System monitoring (quality control of the operating parameters)		30,000
	Site monitoring (performance evaluation including sampling and analysis)		56,250
	5-Year site review, 25,000 (P/F, 5 percent, 5)		4,500
	AS/GAC Subtotal		213,806
Vertical Circulation Well	Equipment maintenance and replacement		
	Building	180,000	
	In-situ air stripping reactor	140,000	
	Synthetic adsorption unit	230,000	
	5 percent of the Subtotal	550,000	27,500
	Electricity		
	Vertical Circulation and air stripping (@ $400 per month)		4,800
	Adsorption unit (regeneration and solvent disposal @ 1,000 per month)		12,000
	Synthetic adsorption unit		
	Blower (@ 1 HP) @ 75 percent efficiency		696
	Manpower (1 X $50,000 per year)		50,000
	System monitoring (quality control of the operating parameters)		10,000
	Site monitoring (performance evaluation including sampling and analysis)		56,250
	5-Year site review 25,000 (A/F, 5 percent, 5)		4,500
	Vertical Circulation Well Subtotal		165,746
	Total O&M costs		379,552
	Present-worth O&M @ (5 percent, 5, OM) * 4.32		**1,639,664**
Total Capital Costs and 5-Year O&M Costs Present Worth			3,625,179

Notes: GAC = granular activated carbon.
PVC = polyvinyl chloride.
LF = linear feet.
FOTW = facility owned treatment works.
P/F = present/future.
A/F = annual/future.

Migration stabilization and prevention of contaminant transfer to the surface water is accomplished by extraction of groundwater with treatment via air stripping and carbon adsorption with discharge of treated effluent to the FOTW.

Reduction of VOC contaminants in groundwater within the OU 1 area is accomplished by *in-situ* air sparging and vapor extraction with onsite treatment of off-gas via synthetic resin adsorption.

Compliance with ARARs. This technology would be designed and operated to meet all chemical-and location-specific ARARs for groundwater remediation. Action-specific ARARs for this technology are listed in Chapter 3.0.

Long-term Effectiveness and Permanence. This focused feasibility study does not address all contaminated groundwater at OU1; however, it will prevent further migration of contaminated groundwater from the OU and would reduce VOC contaminants in groundwater. The overall long-term effectiveness and permanence of this alternative, will be evaluated, in the overall FS for OU1.

Because an overall FS is proposed to be in place before this FFS is terminated, the magnitude of residual risk will be evaluated during implementation of overall FS.

Reduction in Toxicity, Mobility, or Volume. During the *ex-situ* or *in-situ* treatment by air stripping, VOC contaminants are transferred from groundwater to the off-gas. Contaminants in the off-gas are transferred to the absorption media. Regeneration of absorption media results in product recovery. Recovered product may be reused. Removal efficiencies for air-stripping of VOCs is expected to be greater than 90 percent. GAC polish of groundwater transfers contaminants from aqueous phase to solid phase. Absorbed contaminants are permanently destroyed during regeneration.

Short-term Effectiveness. Potential impacts to human health and the environment are minimal for this alternative because the groundwater would either be treated *in-situ* or contained until treatment for *ex-situ* treatment. Also, for *ex-situ* treatment, system shut-off valves and leak detection devices will be in place to prevent potential spills and adverse effects to human health and environment.

A potential risk to human health that may be experienced during the construction and system start-up includes potential exposure to contaminated drill cuttings and VOC vapors. Air monitoring devices and system shutoff controls will be installed to prevent potential adverse effects to the community during implementation. Areas occupied by the treatment systems will be secured by installing physical barriers and signs.

The physics of air movement in saturated porous media are not widely understood. Air movement within the saturated zone is extremely sensitive to formation structure. Additionally, if the sparging system were to be installed closer to residential areas, there is a potential for uncontrolled air movements near the areas where underground utilities were present.

This FFS will be in place until an overall FS is implemented.

Implementability.

Collection and *Ex-situ* Treatment via Air-Stripping, Carbon Adsorption, with offsite discharge to FOTW. Implementability for this technology was described in Alternative 3.

***In-situ* Air Sparging and SVE.** Implementability for this technology was described in Alternative 2.

Cost. Table 6-7 provides a cost estimate for this Alternative including:

- collection and treatment of groundwater treatment via air-stripping, carbon adsorption with offsite discharge to FOTW, and onsite treatment of off-gas; and

- *in-situ* groundwater treatment via air sparging with SVE, and onsite treatment of off-gas.

The capital costs of Alternative 4 are estimated to be $ 2,250,000. Operation, maintenance, and monitoring costs are expected to total $ 422,000 per year for the entire system. These costs are for a 20 gpm *in-situ* treatment system and a

Table 6-7
Cost Estimates for Alternative 4

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Alternative 4: Collection and Treatment via Air Stripping and Carbon Adsorption; In-Situ Treatment via Air Sparging/Soil Vapor Extraction (SVE)

CAPITAL COSTS			
Direct			
Air Sparging/ GAC	Extraction System		62,225
	Building, equipment, piping, and controls		
	Building (3,600 square feet @ $50 per square feet)		180,000
	Shallow-tray air stripper		15,000
	GAC polisher (two-vessel parallel GAC unit)		15,000
	Synthetic adsorption unit (closed loop adsorbent regeneration)		230,000
	Installation (@ 30 percent of air stripper, GAC polisher, synthetic adsorption unit)		105,000
	Site preparation, grading, paving, and fencing		20,000
	Utilities (water, sewer, and electricity)		25,000
	Discharge system (excavation 2-foot by 1-foot trench, PVC piping @ $25/LF)		
	Less than 2,000 feet from the treatment plant to the FOTW/nearest manhole		50,000
Air Sparging/ SVE	Drilling for air sparging and SVE (25 wells @ $5,000)		125,000
	Building, equipment, piping, and controls		
	Air sparging system (15 air spargers @ $ 5,000 each)		75,000
	Soil vapor extraction system (10 SVE wells @ $ 5,000 each)		50,000
	Building (3,600 square feet @ $50 per square foot)		180,000
	Synthetic adsorption unit (closed loop adsorbent regeneration)		230,000
	Installation (@ 30 percent of air sparging system, SVE system, and off-gas treatment)		198,000
	Site preparation, grading, paving, and fencing		20,000
	Utilities (water, sewer, and electricity)		25,000
	Subtotal		1,605,225
Indirect			
	Engineer, construction permit, and administration @ 20 percent		321,045
	Health and safety @ 20 percent		321,045
	Total Capital Costs		2,247,315
ANNUAL OPERATION AND MAINTENANCE (O&M) COSTS			
Air ~~Sparging~~ Stripping/ GAC	Equipment maintenance and replacement		
	Building	180,000	
	Extraction system...pumps	3,225	
	Equipment tank	1,000	
	Trans. pumps	1,200	
	Shallow-tray air stripper	15,000	
	GAC polisher	15,000	
	Synthetic adsorption unit	230,000	
	5 percent of the Subtotal	445,425	22,271

See notes at end of table.

Table 6-7 (Continued)
Cost Estimates for Alternative 4

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Alternative 4: Collection and Treatment via Air Stripping and Carbon Adsorption; In-Situ Treatment via Air Sparging/Soil Vapor Extraction (SVE)

	Electricity, chemicals, and materials		
	Extraction system (3 extractions @ 0.3 horsepower (HP) + 2 trans @ 1 HP) @ $0.08 per KWH & 75 percent efficiency		2,088
	Shallow-tray air stripper		3,000
	GAC unit (including carbon regeneration)		33,000
	Synthetic adsorption including regeneration		
	Blower (@ 1 HP) @ 75 percent efficiency		696
	Electricity, regeneration, and solvent disposal @ 1,000 per month		12,000
	Manpower (1 X $50,000 per year)		50,000
	System monitoring (quality control of the operating parameters)		30,000
	Site monitoring (performance evaluation including sampling and analysis)		56,250
	5-Year site review, 25,000 (P/F, 5 percent, 5)		4,500
	Air Sparging/GAC Subtotal		213,806
Air Sparging/ SVE	Equipment maintenance and replacement		
	Building	180,000	
	Air sparging system	125,000	
	SVE system	75,000	
	Synthetic adsorption unit	230,000	
	5 percent of the Subtotal	610,000	30,500
	Electricity, chemicals, and materials		
	Air sparging system ($1,000 per month)		12,000
	SVE system ($1,000 per month)		12,000
	Synthetic adsorption including regeneration		
	Blower (@ 1 HP) @ 75 percent efficiency		696
	Electricity, regeneration, and solvent disposal @ 1000 per month		12,000
	Manpower (1 X $50,000 per year)		50,000
	System monitoring (quality control of the operating parameters)		30,000
	Site monitoring (performance evaluation including sampling and analysis)		56,250
	5-Year site review, 25,000 (P/F, 5 percent, 5)		4,500
	Air Sparging/SVE Subtotal		207,946
	Total O&M costs		421,752
	Present-worth O&M @ (5 percent, 5, OM) * 4.32		1,821,968
Total Capital Costs and 5-Year O&M Costs Present Worth			4,069,283

Notes: GAC = granular activated carbon.
PVC = polyvinyl chloride.
FOTW = facility owned treatment works.
P/F = present/future.

40 gpm *ex-situ* system, only. These costs are sensitive to the type of contaminants, contaminant concentrations, and target treatment levels. Costs for post-project removal of the recovery systems were not included because it is assumed that the extraction system and the treatment units would be utilized later for a complete restoration of the aquifer at OU 1. The impact on the O & M expenses of the FOTW are not included in this evaluation.

7.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

Table 7-1 summarizes the four remedial alternatives for groundwater migration stabilization and contaminant plume reduction at OU 1, NAS Jacksonville, Florida. Alternatives are compared briefly on the basis of the seven NCP criteria. The comparative analysis evaluates relative performance of each alternative using the criteria on which the detailed analysis of alternatives was completed. The purpose of the comparative analysis is to identify the advantages and disadvantages of the alternatives relative to one another to aid in selecting remedy for groundwater migration stabilization and contaminant plume reduction at OU 1.

Groundwater Migration Stabilization: Groundwater migration stabilization is achieved through extraction, collection and ex-situ treatment of groundwater. UV/oxidation is the technology suggested for ex-situ treatment of groundwater for Alternatives 1 and 2. Whereas, air stripping and GAC adsorption is the technology suggested for Alternatives 3 and 4. Both technologies would treat groundwater to meet pretreatment requirements for FOTW. UV/oxidation provides permanent destruction to VOCs, and there are no waste streams to be managed at the end of the treatment process. Air stripping and GAC adsorption provide for phase transfer of VOCs from aqueous phase to gaseous phase. This process results in generation of contaminated off-gas, which requires further treatment. Short-term risks to human health and environment associated with UV/oxidation are minimal when compared to air stripping and GAC adsorption. Even though, capital costs involved with implementation of UV/oxidation are higher than that of air stripping and GAC adsorption, requirement of an off-gas treatment system for the later technology compromises the capital cost savings (in other words, capital costs of both the technologies are of the same order of magnitude). Operation and maintenance costs associated with UV/oxidation are lesser than those of air stripping and GAC adsorption.

Contaminant Plume Reduction: Contaminant plume reduction is achieved through in-situ treatment of groundwater. Air stripping by vertical circulation wells is the suggested technology for in-situ treatment of groundwater for Alternatives 1 and 3. Air sparging with SVE is the suggested technology for in-situ treatment of groundwater for Alternatives 2 and 4. Both technologies fundamentally work on the same principle, namely phase transfer of VOCs from aqueous phase to gaseous phase. Both technologies require collection of contaminated off-gas and further treatment. Vertical circulation wells provide for a controlled process of phase transfer. Contaminated water is drawn towards a confined chamber, and is circulated through a air stripping reactor. This allows for secured monitoring of phase transfer process, and virtually limits uncontrolled release of VOCs into the atmosphere. On the other hand air sparging with SVE, the mobile media is the air. Air bubbles are transferred through groundwater and are collected via SVE. Since the area sparged is not confined, SVE is always required to be maintained at higher flow rates than the air sparger. Also, is the groundwater to be treated is near residential areas, there is a potential for uncontrolled release of sparged VOCs into the atmosphere. Thus air stripping via vertical circulation wells is relatively superior technology for implementation in such situations. Short term risks for human health and environment associated with implementation of air stripping via vertical circulation wells are minimal compared to those of air sparging with SVE. Capitol costs of in-situ air stripping via vertical circulation wells are lower than those of air sparging with SVE. Operation and maintenance costs are of the same order of magnitude for both the technologies.

Thus alternative involving a combination of ex-situ treatment via UV/oxidation with in-situ treatment by air stripping via vertical circulation wells would be the preferred alternative based on the technical criteria presented in Table 7-1.

Table 7-2 presents a summary of actions involved during implementation of each of the alternatives. Table 7-3 evaluates each action-specific ARAR previously presented in Chapter 3.0 against implementation of each alternative.

Table 7-1
Comparative Analysis of Alternatives

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Criterion	Alternative 1: Collection and Ex-situ Treatment via UV/oxidation with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 2: Collection and Ex-situ treatment via UV/oxidation, Offsite Discharge to FOTW; in-situ treatment via Air Sparging	Alternative 3: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 4: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with offsite discharge to FOTW; in-situ treatment via Air Sparging
Overall Protection of Human Health and Environment				
How risks are eliminated, reduced, or controlled	**RAO 1:** Extraction of groundwater limits migration of groundwater to the surface water stream, *ex-situ* treatment via UV/oxidation destroys VOC contaminants in the off-gas. **RAO 2:** *In-situ* air stripping via vertical circulation well reduces mass of total VOCs in groundwater, onsite treatment of off-gas destroys the VOCs in the off-gas.	**RAO 1:** Analysis is same as for Alternative 1. **RAO 2:** *In-situ* air sparging in conjunction with soil vapor extraction reduces mass of total VOCs in groundwater, onsite treatment of off-gas destroys the VOCs in the off-gas.	**RAO 1.** Extraction of groundwater limits migration of groundwater to the surface water stream, *ex-situ* treatment via air stripping and GAC polish destroys contaminants in the groundwater. Onsite treatment of off-gas destroys the VOCs in off-gas groundwater. **RAO 2.** Analysis is same as for Alternative 1.	**RAO 1.** Analysis is same as for Alternative 3. **RAO 2.** Analysis is same as for Alternative 2.
Short-term or cross-media impact	**RAO 1.** Extraction may lead to a minimal potential for exposure to contaminated groundwater. UV/oxidation permanently destroys VOCs into CO_2 and H_2O. **RAO 2.** *In-situ* air stripping via vertical circulation well, strips the VOCs from within the aquifer by mobilizing the groundwater to the air stripping reactor. Also the treatment process can be monitored and controlled. There is no potential for exposure to contaminated groundwater.	**RAO 1.** Analysis is same as for Alternative 1. **RAO 2.** *In-situ* air sparging volatilizes the VOCs in groundwater from within the aquifer. Unlike Alternative 1, air is mobilized to the contaminated groundwater. Air movement within the saturated zone is difficult to predict and monitor. There is a potential for uncontrolled release of VOCs into the vadose zone, and consequently to the atmosphere. A well designed SVE system should prevent cross-media impact of VOCs.	**RAO 1.** Extraction may result in potential for minimal exposure to contaminated groundwater. Also, handling of spent carbon from GAC units will result in potential exposure to contaminants. **RAO 2.** Analysis is same as for Alternative 1.	**RAO 1.** Analysis is same as for Alternative 3. **RAO 2.** Analysis is same as for Alternative 2.
Compliance with ARARS				
Chemical-, location-, and action-specific ARARs	**RAO 1, and RAO 2.** Complies with federal and state ARARs for groundwater protection. This focused effort do not consider aquifer restoration.	Analysis is same as Alternative 1.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.

See notes at end of table.

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Table 7-1 (Continued)
Comparative Analysis of Alternatives

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Criterion	Alternative 1: Collection and Ex-situ Treatment via UV/oxidation with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 2: Collection and Ex-situ treatment via UV/oxidation, Offsite Discharge to FOTW; in-situ treatment via Air Sparging	Alternative 3: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 4: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with offsite discharge to FOTW; in-situ treatment via Air Sparging
Long-term Effectiveness and Permanence				
Magnitude of residual risk	**RAO 1.** Groundwater extracted during Migration Stabilization would be treated to meet pretreatment requirements for FOTW. The residual amount of VOC contaminant mass in the groundwater will depend on the length of operation of the extraction and treatment system. Current efforts do not consider aquifer restoration. **RAO 2.** In-situ air stripping reduces total VOC mass in the groundwater at the OU. Residual mass of VOCs will depend on the length of operation of the treatment system. Appendix F presents the remediation time frame for total VOCs in the groundwater.	Analysis is same as Alternative 1.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.
Adequacy of Controls	**RAO 1.** Tank-full shutoffs would prevent overflow. Bermed concrete pads would contain minor spills. Influent and effluent monitoring ports would provide system performance checks. Interlocks will be provided to alarm and/or shutdown the UV/Oxidation system during performance failure. **RAO 2.** Two monitoring wells will be included in each vertical circulation well: one near the extraction screen, the other near the discharge screen. Influent and effluent monitoring ports would provide system performance checks. Off-gas will be collected under negative pressure and effluent off-gas discharge will be monitored for quality and flow rates.	**RAO 1.** Analysis is same as for Alternative 1. **RAO 2.** Vadose zone and saturated zone will be continuously monitored to prevent uncontrolled diffusion of VOCs into the atmosphere. Flow rates for the SVE will be maintained at higher levels than those of the Air Sparging System. Air monitoring devises will be installed for ambient air quality monitoring.	Analysis is same as for Alternative 1.	**RAO 1.** Analysis is same as for Alternative 1. **RAO 2.** Analysis is same as for Alternative 2.

See notes at end of table.

Table 7-1 (Continued)
Comparative Analysis of Alternatives

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Criterion	Alternative 1: Collection and Ex-situ Treatment via UV/oxidation with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 2: Collection and Ex-situ treatment via UV/oxidation, Offsite Discharge to FOTW; in-situ treatment via Air Sparging	Alternative 3: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 4: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with offsite discharge to FOTW; in-situ treatment via Air Sparging
Reliability of Controls	**RAO 1 and RAO 2.** Technology controls are well demonstrated to be effective. Reliability would be ensured by proper and continual system maintenance.	**RAO 1.** Analysis is same as for Alternative 1. **RAO 2.** Pilot scale tests would need to be performed to evaluate the design parameters and reliability of controls.	Analysis is same as for Alternative 1.	**RAO 1.** Analysis is same as for Alternative 1. **RAO 2.** Analysis is same as for Alternative 2.
Reduction of Mobility, Toxicity, or Volume				
Treatment process and remedy	**RAO 1.** Extracted groundwater will be treated via UV/oxidation and treated to meet pretreatment levels for FOTW discharge. **RAO 2.** Circulating groundwater will be treated via air stripping. The off-gas will treated via synthetic resin adsorption and closed loop regeneration of adsorbent.	**RAO 1.** Analysis is same as for Alternative 1. **RAO 2.** As injected air bubbles from the air sparger rise through the saturated zone, dissolved VOCs are transferred from the aqueous phase to the vapor phase by diffusion. VOCs diffused into the vadose zone are captured by a SVE system. Off-gas will be treated onsite via synthetic resin adsorption.	**RAO 1.** Extracted groundwater will be treated via air stripping and GAC polish. Off-gas will be treated via synthetic resin adsorption. **RAO 2.** Analysis is same as for Alternative 1.	**RAO 1.** Analysis is same as for Alternative 3. **RAO 2.** Analysis is same as for Alternative 2.
Amount of hazardous material destroyed or treated	**RAO 1.** Estimated flow rate of 25 gpm is considered for a period of 5 years yielding a total volume of 65 X 10^6 gallons. This volume accounts for 10 percent of the volume of VOC contaminated groundwater. Preliminary estimates on total mass of VOCs in groundwater is approximately 11,000 kg. **RAO 2.** An estimated flow rate of 20 gpm per well are considered for a period of 5 years yielding a total volume of 53 X 10^6 gallons passing through the air stripping reactor. This volume accounts for 8 percent of the total volume of the contaminant plume.	**RAO 1.** Analysis is same as for Alternative 1. **RAO 2.** Based on the preliminary design calculations, as presented in Appendix F, in-situ air sparging reduces the total mass of VOCs by 30 percent in a period of 5 years.	**RAO 1.** Analysis is same as for Alternative 2. **RAO 2.** Analysis is same as for Alternative 1.	**RAO 1.** Analysis is same as for Alternative 2. **RAO 2.** Analysis is same as for Alternative 2.

See notes at end of table.

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Table 7-1 (Continued)
Comparative Analysis of Alternatives

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Criterion	Alternative 1: Collection and Ex-situ Treatment via UV/oxidation with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 2: Collection and Ex-situ treatment via UV/oxidation, Offsite Discharge to FOTW; in-situ treatment via Air Sparging	Alternative 3: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 4: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with offsite discharge to FOTW; in-situ treatment via Air Sparging
Reduction of mobility, toxicity, or volume through treatment	**RAO 1.** Managing the migration of groundwater and providing treatment via UV/Oxidation significantly reduces mobility, toxicity, and volume of the contaminants. **RAO 2.** In-situ air stripping via vertical circulation well provides a significant and permanent reduction in toxicity, mobility, and volume of VOC contaminants. Off-gas treatment via synthetic adsorption provides a permanent destruction of the contaminants.	**RAO 1.** Analysis is same as for Alternative 1. **RAO 2.** In-situ air sparging with SVE provides mass transfer of VOCs from liquid phase to gaseous phase. Off-gas treatment via synthetic adsorption provides permanent destruction to the contaminants.	**RAO 1.** Managing the migration of groundwater and providing treatment via air stripping and GAC polish, and onsite treatment of off-gas significantly reduces mobility, toxicity, and volume of the contaminants. **RAO 2.** Analysis is same as for Alternative 1.	**RAO 1.** Analysis is same as for Alternative 3. **RAO 2.** Analysis is same as for Alternative 2.
Irreversibility of treatment	**RAO 1.** Ex-situ treatment via UV/Oxidation is an irreversible process. **RAO 2.** In-situ groundwater remediation through air stripping with off-gas treatment via synthetic resin adsorption is irreversible.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.
Type and quantity of treatment residual	**RAO 1.** None. **RAO 2.** Recovered condensed VOCs.	Analysis is same as for Alternative 1.	**RAO 1, and RAO 2.** Recovered condensed VOCs.	Analysis is same as for Alternative 3.

See notes at end of table.

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Table 7-1 (Continued)
Comparative Analysis of Alternatives

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Criterion	Alternative 1: Collection and Ex-situ Treatment via UV/oxidation with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 2: Collection and Ex-situ treatment via UV/oxidation, Offsite Discharge to FOTW; in-situ treatment via Air Sparging	Alternative 3: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 4: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with offsite discharge to FOTW; in-situ treatment via Air Sparging
Short-term Effectiveness				
Protection of community during remedial action	**RAO 1.** Tank-full shutoffs would prevent overflow. Bermed concrete pads would contain minor spills. Influent and effluent monitoring ports would provide system performance checks. Interlocks will be provided to alarm and/or shutdown the UV/Oxidation system during performance failure. Physical barriers and display signs will be installed around the treatment system. **RAO 2.** Two monitoring wells will be included in each vertical circulation well: one near the extraction screen, the other near the discharge screen. Influent and effluent monitoring ports would provide system performance checks. Off-gas will be collected under negative pressure and effluent discharge will be monitored for quality and flow rates.	**RAO 1.** Analysis is same as for Alternative 1. **RAO 2.** Vadose zone will be monitored to predict the movement of VOC vapors by installing a series of piezometers in an area downgradient of the SVE system and upgradient of residential areas. Air monitoring devices will be installed at these piezometers and system shut-off valves will be installed on the air-sparging unit.	**RAO 1.** Tank-full shutoffs would prevent overflow. Bermed concrete pads would contain minor spills. Influent and effluent monitoring ports would provide system performance checks. Interlocks will be provided to alarm and/or shutdown the air stripping, GAC polish, and off-gas treatment systems during performance failure. Physical barriers and display signs will be installed around the treatment system. **RAO 2.** Analysis is same as for Alternative 1.	**RAO 1.** Analysis is same as for Alternative 3. **RAO 2.** Analysis is same as for Alternative 1.
Protection of workers during remedial actions	**RAO 1 and RAO 2.** Potential for exposure to contaminated drill cuttings and vapors is associated with the installation of wells. Adequate health and safety measures will be in place to protect the safety of workers.	Analysis is same as Alternative 1.	**RAO 1.** Analysis is same as for Alternative 1. In addition, there will be a potential for exposure to contaminants while handling spent carbon from GAC beds for regeneration. **RAO 2.** Analysis is same as for Alternative 1.	**RAO 1.** Analysis is same as for Alternative 3. **RAO 2.** Analysis is same as for Alternative 2.

See notes at end of table.

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Table 7-1 (Continued)
Comparative Analysis of Alternatives

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Criterion	Alternative 1: Collection and Ex-situ Treatment via UV/oxidation with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 2: Collection and Ex-situ treatment via UV/oxidation, Offsite Discharge to FOTW; in-situ treatment via Air Sparging	Alternative 3: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 4: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with offsite discharge to FOTW; in-situ treatment via Air Sparging
Environmental impacts	**RAO 1, and RAO 2.** Minimal impacts (i.e., tree removal) are expected during implementation of this alternative.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.
Time until remedial action objectives are achieved	**RAO 1, and RAO 2.** This operation should be a continuing process, until a comprehensive aquifer restoration is in place, or the contaminant plume is completely captured.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.
Implementability				
Ability to construct technology	**RAO 1.** Vendors are available to design and install the UV/oxidation unit within a minimum period of notice. **RAO 2.** In-situ air stripping via vertical circulation well can be designed and prefabricated before installation. Vendors are available to supply the treatment unit with a minimum period of notice.	**RAO 1.** Analysis is same as Alternative 1. **RAO 2.** Air sparging and SVE systems can be designed and installed. Pilot scale studies are required to evaluate the radii of influence of injection and extraction wells.	**RAO 1.** The extraction system is easy to install. Vendors could provide air stripper, GAC adsorption unit, synthetic adsorption unit for off-gas treatment within certain minimum period of notice. Evaluation of optimum operating conditions requires bench scale studies. **RAO 2.** Analysis is same as for Alternative 1.	**RAO 1.** Analysis is same as for Alternative 3. **RAO 2.** Analysis is same as for Alternative 2.
Reliability of technology	**RAO 1 and RAO 2.** Remedial action objectives would be met. Technology has been successfully implemented at other CERCLA sites.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.
Ease of undertaking additional remedial action, if necessary	**RAO 1 and RAO 2.** Both the ex-situ UV/oxidation system, and in-situ air stripping unit may be usable for future groundwater remedial actions. Does not limit or restrict any further remedial actions at the site.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.

See notes at end of table.

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Table 7-1 (Continued)
Comparative Analysis of Alternatives

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Criterion	Alternative 1: Collection and Ex-situ Treatment via UV/oxidation with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 2: Collection and Ex-situ treatment via UV/oxidation, Offsite Discharge to FOTW; in-situ treatment via Air Sparging	Alternative 3: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 4: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with offsite discharge to FOTW; in-situ treatment via Air Sparging
Monitoring considerations	**RAO 1.** Factors affecting performance of the UV/Oxidation process and include: influent water quality, flow rate, UV light energy from the lamps, dosage of H_2O_2 or O_3, and the effluent water quality. Influent and effluent water quality will be monitored once in a week for the first 15 weeks and then quarterly for the next five years. A Programmed Logic Control included as part of UV/oxidation system provides a continuous monitoring for system performance. **RAO 2.** Factors affecting the performance of the air stripping reactor will be monitored. These factors include: extraction and injection flow rates, natural gradient of groundwater, width of capture zone, off-gas concentrations, and humidity and temperature of off-gas. Samples from the extraction and injection ports will be monitored along with the monitoring well samples from the upgradient and down gradient wells.	Analysis is same as for Alternative 1.	**RAO 1.** Factors affecting performance of air stripper, and GAC polish, and onsite treatment of off-gas requiring monitoring include: influent water flow rate and quality, air to water ratio, and effluent water flow rate and quality, influent and effluent off-gas flow rates, and concentrations. **RAO 2.** Same as for alternative 1.	**RAO 1.** Analysis is same as for Alternative 3. **RAO 2.** Analysis is same as for Alternative 2.
Coordination with other agencies	**RAO 1 and RAO 2.** Coordination with NAS Jacksonville and regulators required for an initial period of 5 years.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.

See notes at end of table.

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Table 7-1 (Continued)
Comparative Analysis of Alternatives

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Criterion	Alternative 1: Collection and Ex-situ Treatment via UV/oxidation with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 2: Collection and Ex-situ treatment via UV/oxidation, Offsite Discharge to FOTW; in-situ treatment via Air Sparging	Alternative 3: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 4: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with offsite discharge to FOTW; in-situ treatment via Air Sparging
Availability and capacity of treatment, storage, and disposal (TSD) services	**RAO 1.** Groundwater will be treated to meet the pretreatment standards required for FOTW. Treated groundwater will be discharged into FOTW. FOTW currently has the capacity to receive the treated groundwater from the UV/oxidation system. **RAO 2.** Groundwater will be treated in-situ and there will be an off-gas stream generated. Off-gas will be treated onsite. Off-gas treatment results in generation of solvents. These solvents may be reused, or disposed offsite.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.
Availability of technologies, equipment, and specialists	**RAO 1, and RAO 2.** Drilling contractors, treatment unit vendors, monitoring equipment, and laboratories are available.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.
Ability to obtain approval from other agencies	**RAO 1, and RAO 2.** Approval from State and USEPA necessary prior to disposal of treated groundwater into the base FOTW. Approval should not be difficult.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.	Analysis is same as for Alternative 1.

See notes at end of table.

Table 7-1 (Continued)
Comparative Analysis of Alternatives

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

Criterion	Alternative 1: Collection and Ex-situ Treatment via UV/oxidation with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 2: Collection and Ex-situ treatment via UV/oxidation, Offsite Discharge to FOTW; in-situ treatment via Air Sparging	Alternative 3: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with Offsite Discharge to FOTW; in-situ treatment via Air Stripping by vertical circulation well	Alternative 4: Collection and Ex-situ treatment via Air Stripping and Carbon Adsorption with offsite discharge to FOTW; in-situ treatment via Air Sparging
Cost				
Capital costs	$ 1,615,000	$ 1,873,000	$ 1,986,000	$ 2,250,000
Annual operation and maintenance costs	$ 366,000	$ 404,400	$ 380,000	$ 422,000
Total Present worth (assuming a 5 year operation at 5 percent discount)	$ 3,189,000	$ 3,650,000	$ 3,626,000	$ 4,070,000

Notes: UV = ultraviolet.
FOTW = facility owned treatment works.
RAO = remedial action objectives.
VOC = volatile organic compound.
CO_2 = carbon dioxide.
H_2O = water.
SVE = soil vapor extraction.
GAC = granular activated carbon.
ARARs = applicable or relevant and appropriate requirements.
gpm = gallons per minute.
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
H_2O_2 = hydrogen peroxide.
NAS = Naval Air Station.

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Table 7-2
List of Actions During Implementation of Each Remedial Alternative

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

		Alternative 1		Alternative 2		Alternative 3		Alternative 4	
		Ex-Situ UV/Ox	In-Situ VCW	Ex-Situ UV/Ox	In-Situ AS/SVE	Ex-Situ AS/GAS	In-Situ VCW	Ex-Situ AS/GAS	In-Situ AS/SVE
1	Site Clearing and Preparation	x	x	x	x	x	x	x	x
2	Excavation	x		x	x	x		x	x
3	Borehole Drilling	x	x	x	x	x	x	x	x
4	Installation of Vertical Circulation Wells		x				x		
5	Installation of Extraction Wells	x		x		x		x	
6	Installation of Air Sparging Wells				x				x
7	Installation of Soil Vapor Extraction Wells				x				x
8	Installation of Piping	x			x	x		x	x
9	Installation of Off-Gas Treatment Unit		x		x	x	x	x	x
10	Groundwater Extraction	x		x		x		x	
11	Groundwater Collection	x		x		x		x	
12	In-Situ Air Stripping via Vertical Collection Well		x				x		
13	In-Situ Air Sparging and Soil Vapor Extraction				x				x
14	Ex-Situ Treatment via UV/ox	x		x					
15	Ex-Situ Treatment via Air Stripping					x		x	
16	Ex-Situ Treatment via GAC					x		x	
17	Off-Gas Collection		x		x	x	x	x	x
18	Off-Gas Treatment (Synthetic Resin Adsorption)		x		x	x	x	x	x
19	Treated Off-Gas Discharge to Atmosphere		x		x	x	x	x	x
20	Treated Groundwater Discharge to FOTW	x		x		x		x	
21	Solvent Recovery and Recycle		x		x	x	x	x	x

Notes: UV/Ox = Ultraviolet/Oxidation.
VCW = vertical circulation well.
SVE = soil vapor extraction.
AS = air sparging.
GAC = granular activated carbon.

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Table 7-3
List of Action -Specific ARARs for Each Remedial Action

Focused Remedial Investigation and
Focused Feasibility Study for Addressing Groundwater Remediation
Operable Unit 1, NAS Jacksonville
Jacksonville, Florida

		Alternative 1		Alternative 2		Alternative 3		Alternative 4	
		Ex-Situ UV/Ox	In-Situ VCW	Ex-Situ UV/Ox	In-Situ AS/SVE	Ex-Situ AS/GAC	In-Situ VCW	Ex-Situ AS/GAC	In-Situ AS/SVE
1	Clean Air Act (CAA), NAAQS, 40 CFR Part 50	RAR	AR	RAR	AR	RAR	AR	AR	AR
2	Clean Air Act (CAA), NSPS, 40 CFR Part 60								
3	CWA, NPDES, 40 CFR Parts 122, and 125	RAR		RAR		RAR		RAR	
4	OSHA, General Industry Standards, 29 CFR Part 1910	AR	AR	AR	AR	AR	AR	AR	AR
5	OSHA, Record Keeping, Reporting, etc., 29 CFR Part 1904	AR	AR	AR	AR	AR	AR	AR	AR
6	OSHA, Health and Safety Standards, 29 CFR 1926	AR	AR	AR	AR	AR	AR	AR	AR
7	RCRA, Use and Management of Containers, 40 CFR Part 264, Subpart I	RAR	RAR	RAR	RAR	RAR	RAR	RAR	RAR
8	RCRA, Generators of Hazardous Waste, 40 CFR Part 262	RAR	RAR	RAR	RAR	RAR	RAR	RAR	RAR
9	RCRA, Manifest System, Record Keeping and Reporting, 40 CFR 264, Subpart E		AR		AR	AR	AR	AR	AR
10	RCRA, Contingency Plan and Emergency procedures, 40 CFR Part 264, Subpart D	AR	AR	AR	AR	AR	AR	AR	AR
11	Federal Facility Compliance Act (FFCA)								
12	Chapter 17-2, FAC, Florida Air Pollution Rules, September 1990		AR		AR	AR	AR	AR	AR
13	Chapter 17-730, FAC, Florida Hazardous Waste Rules, August 1990								
14	Chapter 17-736, FAC, Florida Rules of Hazardous Waste Warning Signs, July 1990	AR	AR	AR	AR	AR	AR	AR	AR
15	Chapter 17-770, FAC, Florida Petroleum Contaminated Site Cleanup Criteria, February 1990								

Notes: UV/Ox = Ultraviolet/Oxidation.
VCW = vertical circulation well.
AS =
SVE = soil vapor extraction.
GAC = granular activated carbon.

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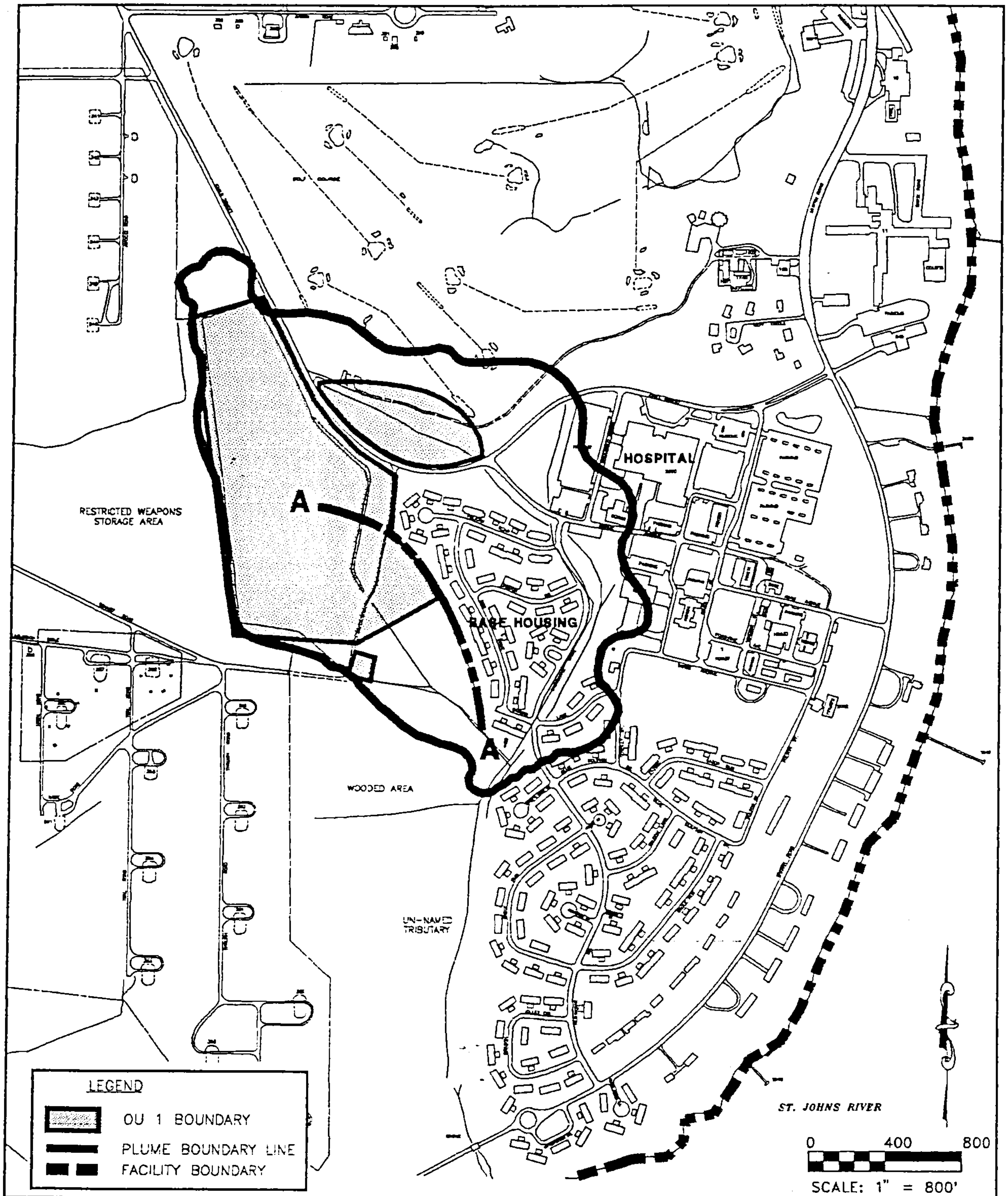

FIGURE 2-5
LOCATION OF PROFILES A-A' AT OU 1 (JULY 1993 AND MARCH 1994 DATA)

FOCUSED RI/FS CONTAMINANT PLUME REDUCTION AT OU 1

NAS JACKSONVILLE JACKSONVILLE, FLORIDA

OU1PUMP/DRM/7-14-94

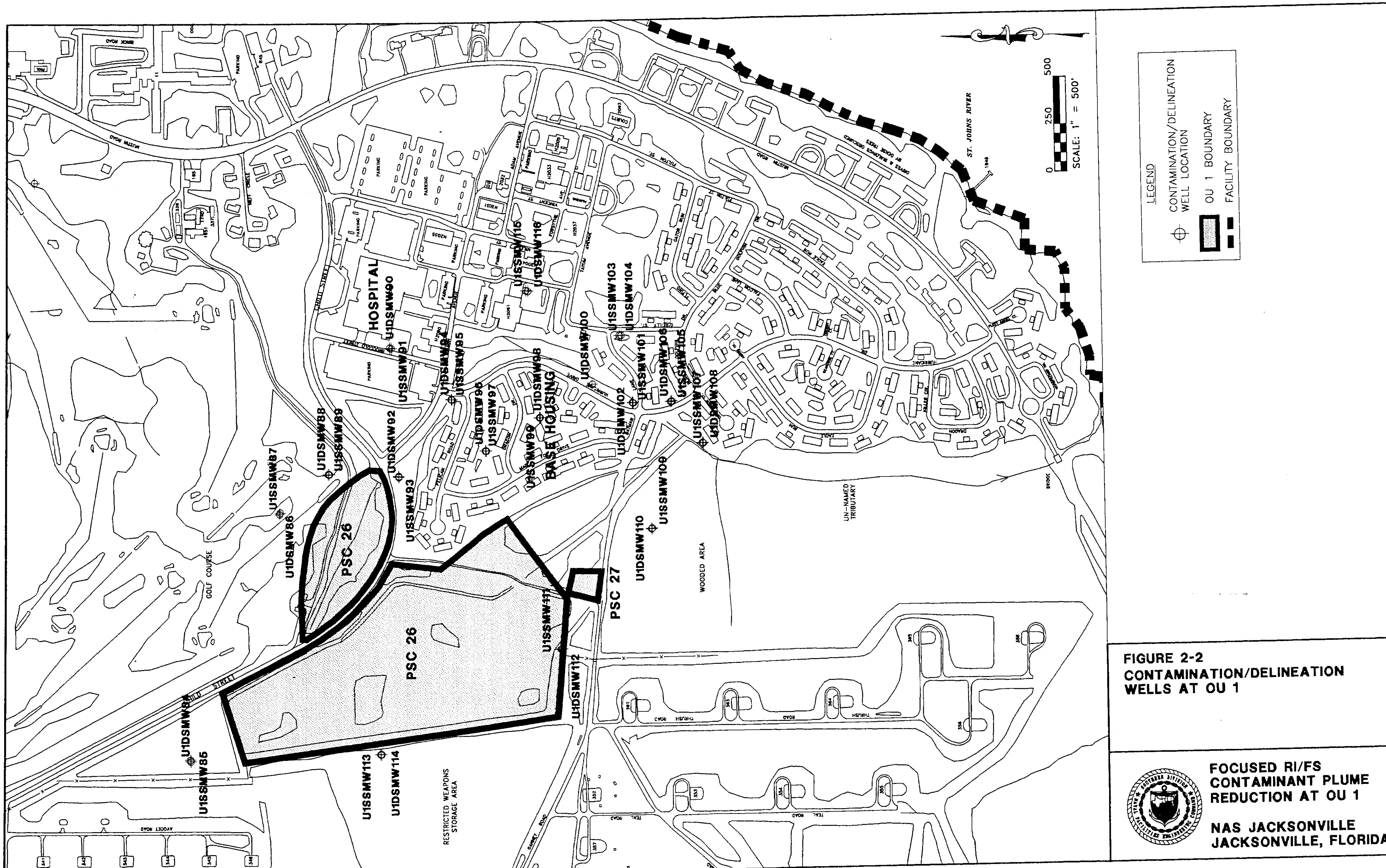

FIGURE 2-2
CONTAMINATION/DELINEATION
WELLS AT OU 1

FOCUSED RI/FS
CONTAMINANT PLUME
REDUCTION AT OU 1

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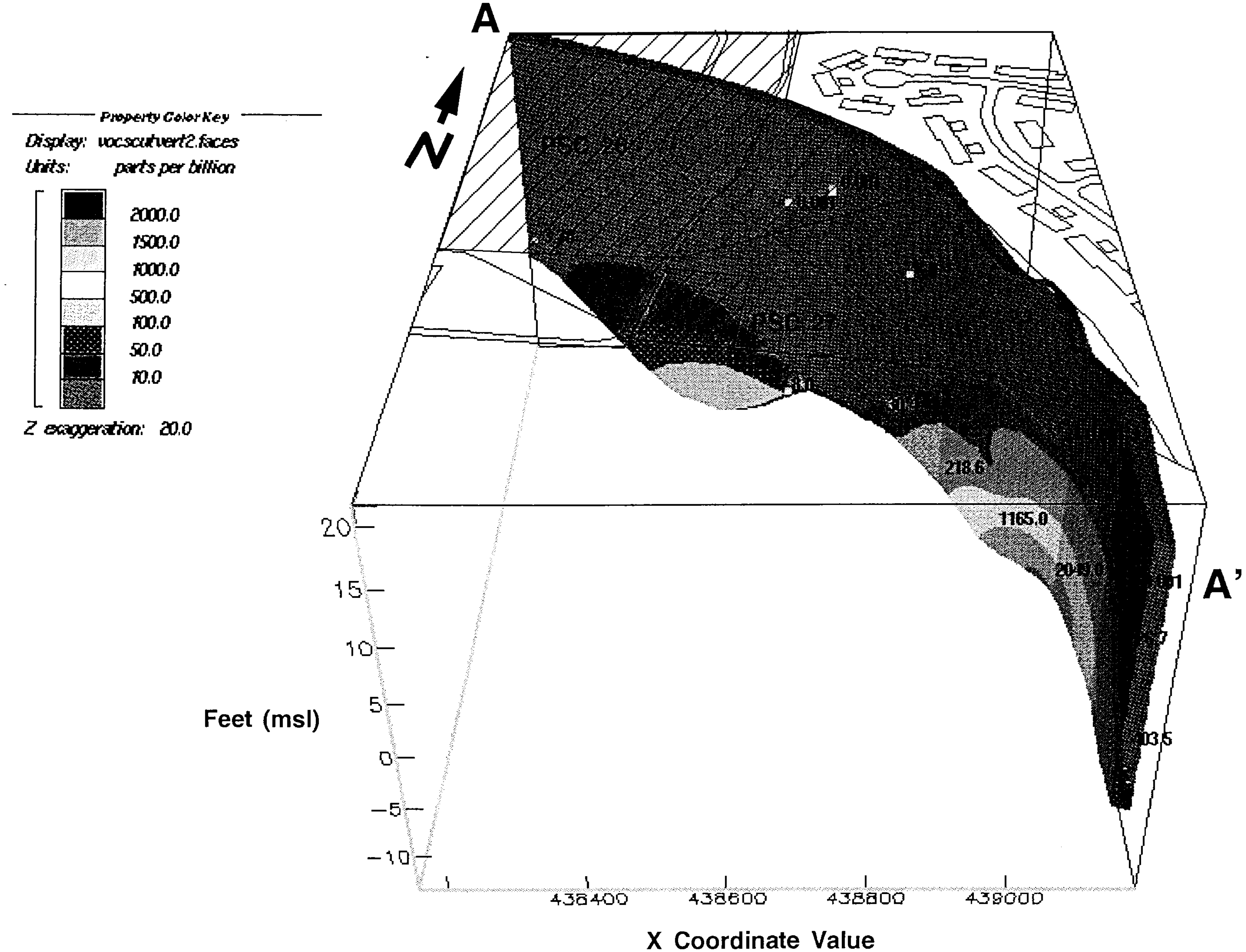

FIGURE 2-6
PROFILE A-A', TOTAL VOCs IN GROUNDWATER AT OU 1 (MAY 1992 AND JULY 1993 DATA)

FOCUSED RI/FS
CONTAMINANT PLUME REDUCTION AT OU 1

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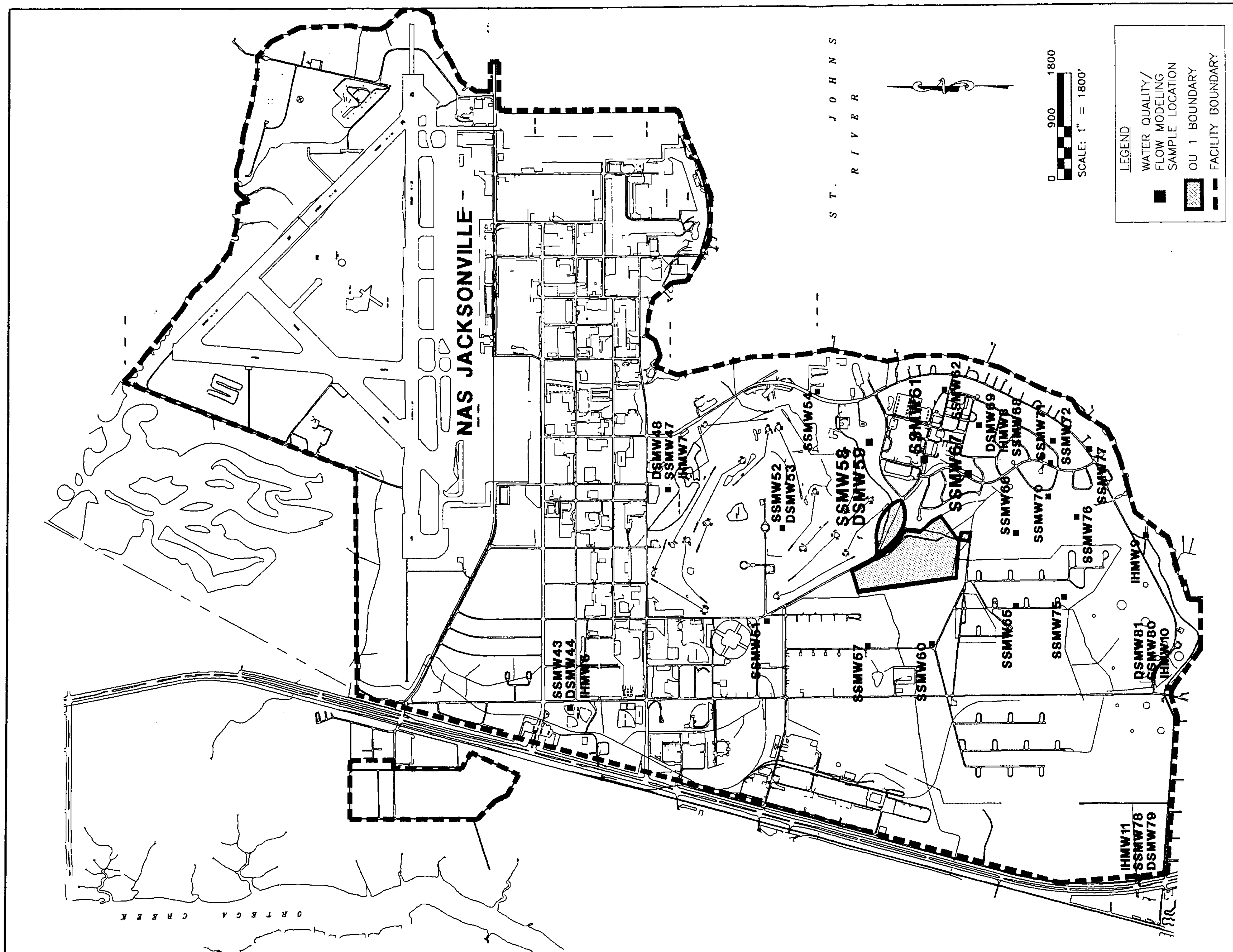

FIGURE 2-3
MONITORING WELL LOCATIONS FOR WATER QUALITY ASSESSMENT AND FLOW MODELING

FOCUSED RI/FS CONTAMINANT PLUME REDUCTION AT OU 1

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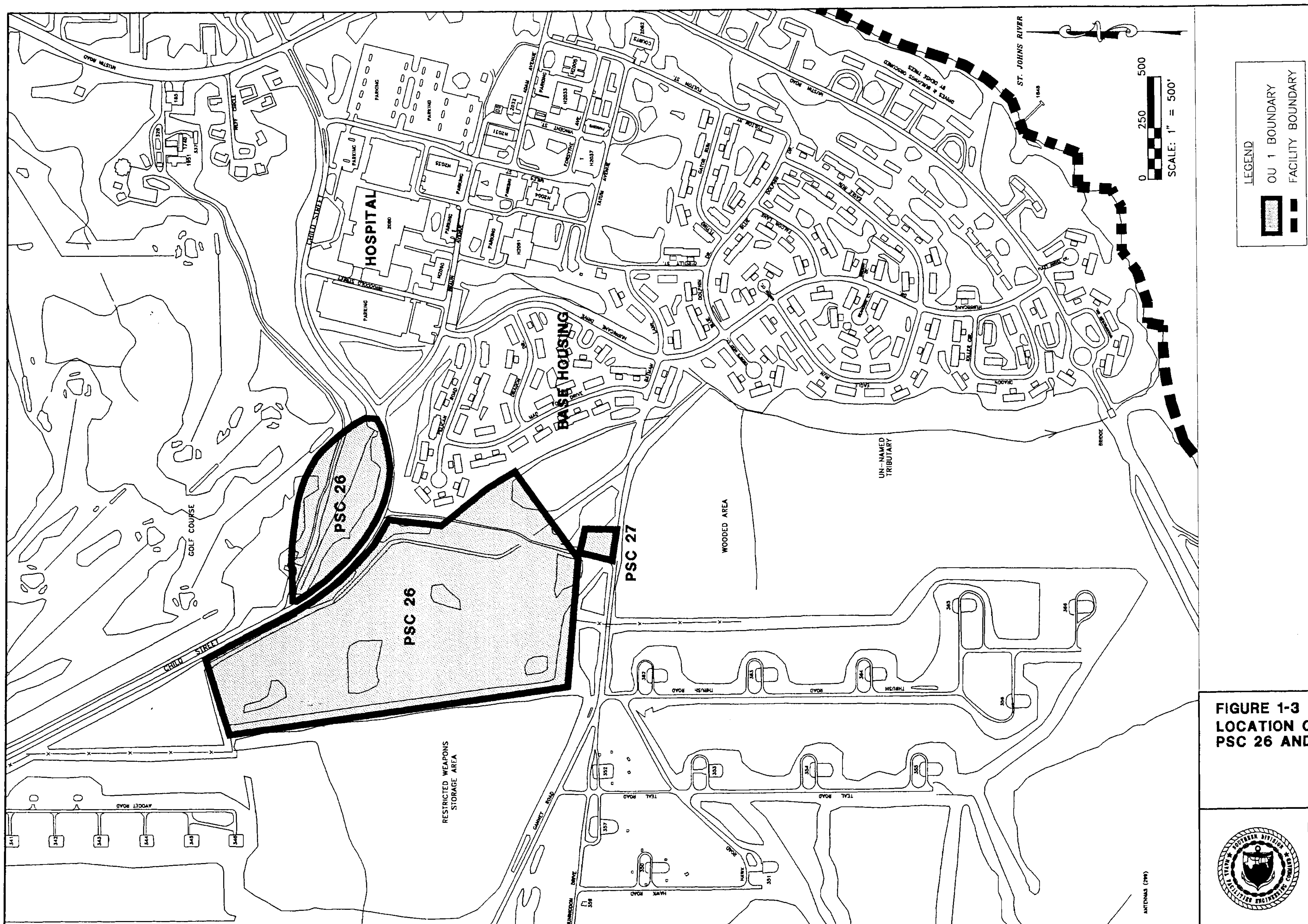

FIGURE 1-3
LOCATION OF OU 1 AREA, PSC 26 AND PSC 27

FOCUSED RI/FS
CONTAMINANT PLUME REDUCTION AT OU 1

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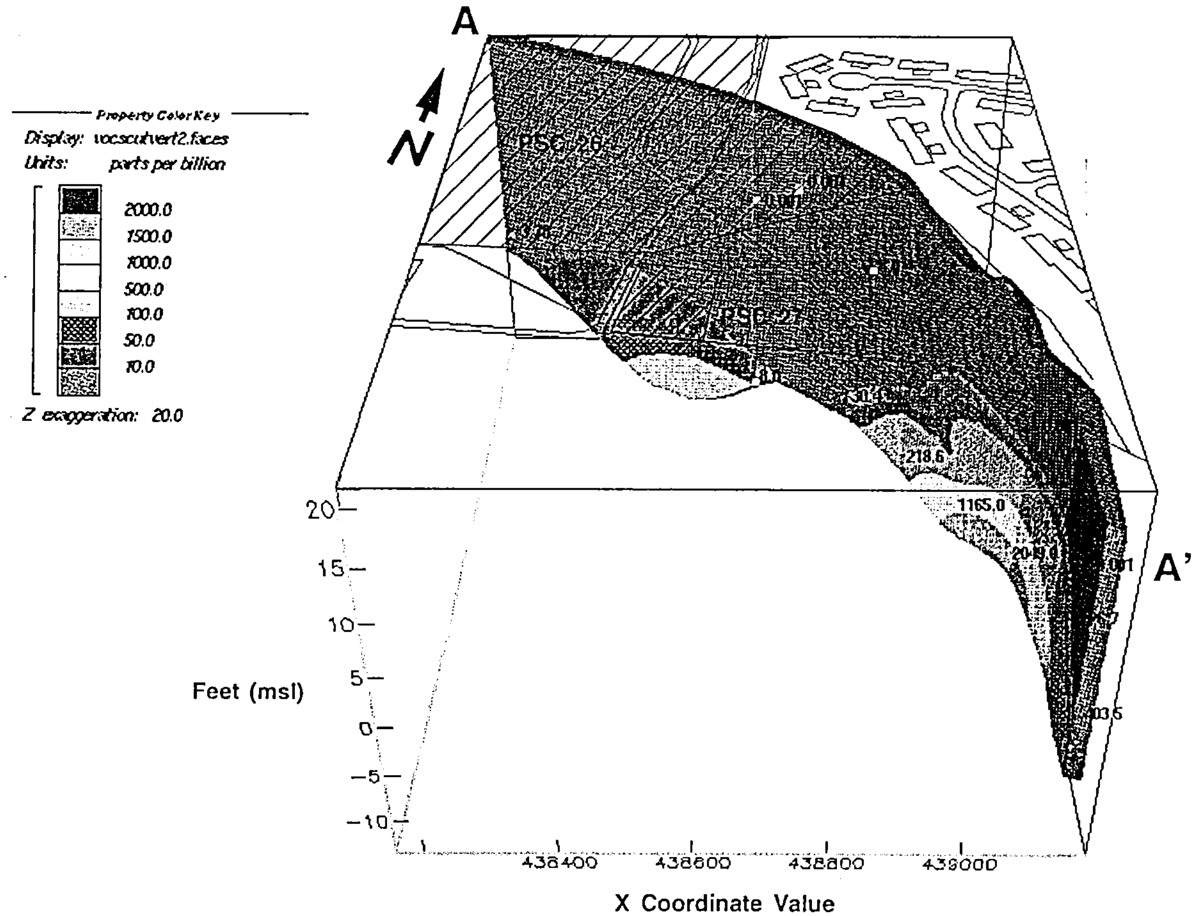

FIGURE 2-6
PROFILE A-A', TOTAL VOCs IN GROUNDWATER AT OU 1 (MAY 1992 AND JULY 1993 DATA)

FOCUSED RI/FS
CONTAMINANT PLUME REDUCTION AT OU 1

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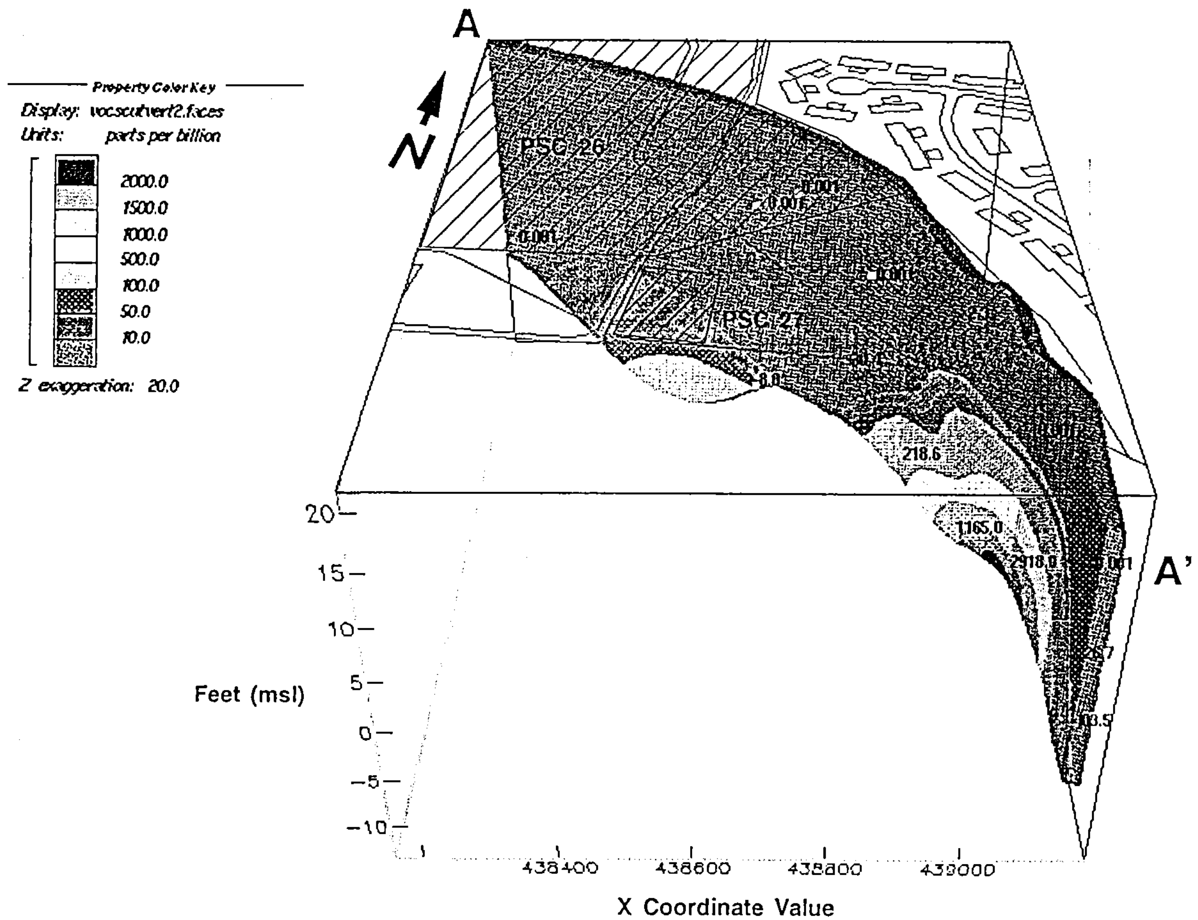

FIGURE 2-7
PROFILE A-A', TOTAL VOCs IN GROUNDWATER AT OU 1 (JULY 1993 AND MARCH 1994 DATA)

FOCUSED RI/FS
CONTAMINANT PLUME REDUCTION AT OU 1

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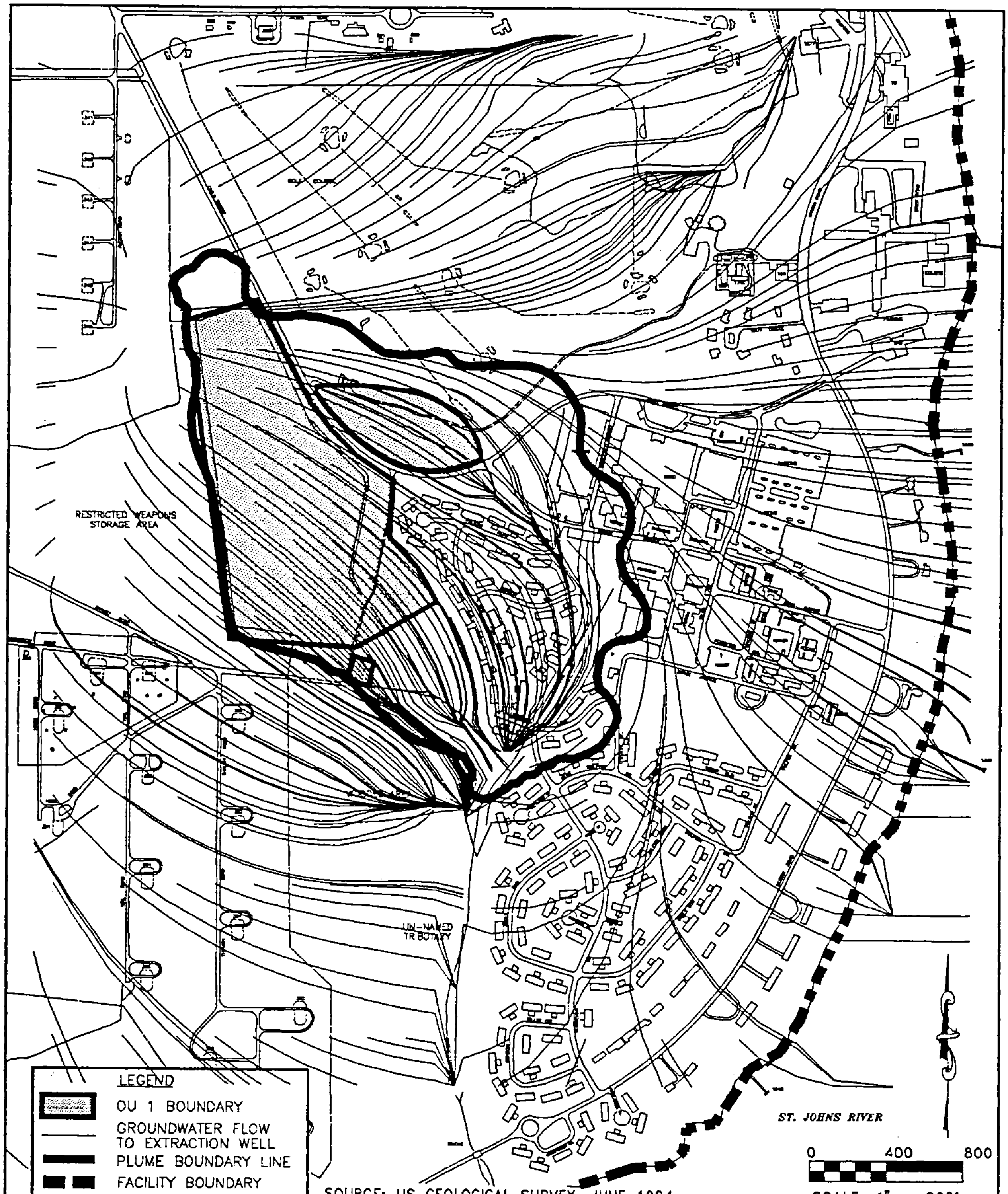

SOURCE: US GEOLOGICAL SURVEY, JUNE 1994.

FIGURE 2-8
GROUNDWATER FLOW LINES AT OU 1

FOCUSED RI/FS
CONTAMINANT PLUME REDUCTION AT OU 1

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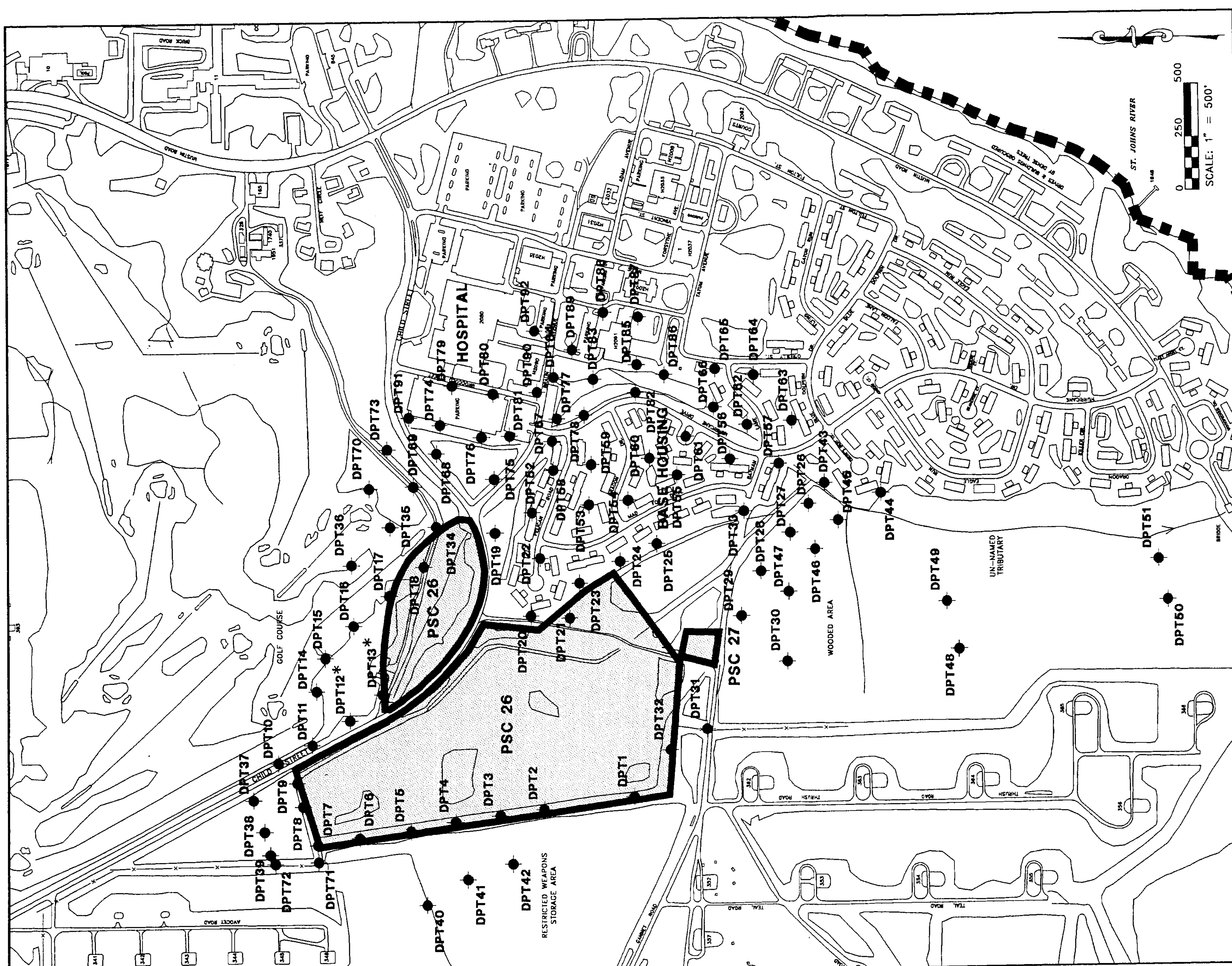

FIGURE 2-1
DPT GROUNDWATER SAMPLE LOCATIONS AT OU1

FOCUSED RI/FS
CONTAMINANT PLUME STABILIZATION AT OU1

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